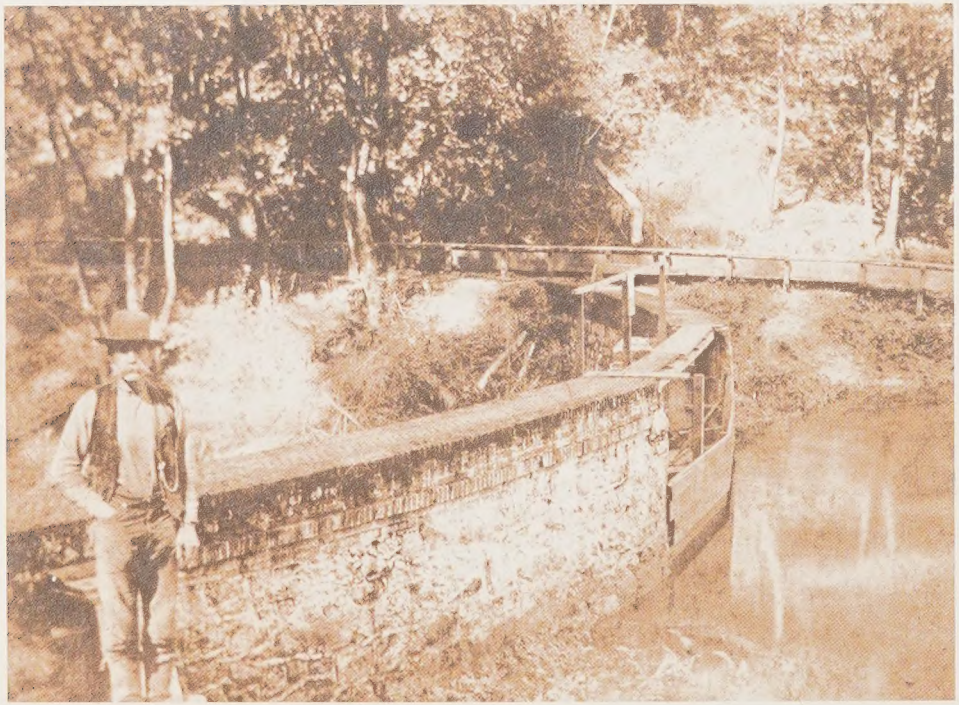
City and County
of San Francisco

SAN FRANCISCO WATER & POWER

A HISTORY OF THE MUNICIPAL WATER DEPARTMENT AND HETCH HETCHY SYSTEM



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CHRONOLOGY

1769	Expedition of Portola and Ortega
1773 Nov 30	Expedition of Moncada and Palou
1776	Presidio Pueblo and Mission San Francisco established by de Anza
1825	Ending of Spanish royal rule in California
1833	Mexican Secularization Act opens California world trade
1835	Trading post established at Yerba Buena Cove
1836	First adobe building built at Yerba Buena
1846 Jul 9	Pueblo of Yerba Buena taken by U.S.S. Portsmouth
1846	Pueblo of Yerba Buena proclaimed Town of San Francisco
1849	Drinking water sold by the barrel and bucket in the streets
1850-1852	San Francisco devastated by fire six times
1851	Mountain Lake Water Company formed
1851	Sausalito Water and Steam Tug Company importing water from Marin
1853	Mountain Lake Water Company granted first of several time extensions
1856	San Mateo lands excluded in San Francisco City and County consolidation. First pipelines laid in the City
1857	San Francisco City Water Company brings water from Lobos Creek
1858	Spring Valley Water Works franchised by State Legislature
1860 Apr	Alexei W. von Schmidt becomes chief engineer of Spring Valley
1860	U.S. Census reports San Francisco population at 78,000
1860	Spring Valley takes over Islais and Salinas Water Company
1861	Construction of first Pilarcitos Dam and Tunnel
1862 Jul 4	First peninsula water enters San Francisco. Spring Valley Water Works now rivals San Francisco City Water Works
1863 Dec	First Pilarcitos Dam completed
1864	A.W. von Schmidt leaves Spring Valley
1864 Oct 8	Calvin Brown, Spring Valley chief engineer, hires Hermann Schussler to raise main Pilarcitos Dam
1864	San Francisco City Water Works taps into Spring Valley water main
1865 Feb 13	Spring Valley buys out San Francisco City Water Works
1865	Schussler starts second long tunnel on Pilarcitos conduit line
1866 May	Schussler named chief engineer of Spring Valley Water Works
1867	Main Pilarcitos Dam completed to height of 70 feet
1868	Spring Valley buys San Andrés Valley and watershed
1868 Apr	Schussler starts construction of San Andrés Dam
1868 Aug	Spring Valley acquires rights to Lake Merced
1869	Spring Valley Water Works sues San Francisco for water payment for "municipal purposes"
1870	State legislature considers bill by Lake Tahoe Water Company to tunnel through Sierra Nevada. San Francisco Mayor Selby vetos Board of Supervisors $6 million bond issue as "inappropriate"
1870 Jun	Lock's Creek Line Aqueduct (Stone Dam Tunnel #1) started
1871	Stone Dam and Lock's Creek Tunnel completed. Lock's Creek Line developed
1873	First municipal efforts to buy out Spring Valley Water Works
1875	San Andrés Dam increased in height
1875	Main Pilarcitos Dam raised to 95 feet
1875 Apr 19	City Engineer T.R. Scowden recommends San Francisco buy Calaveras site
1875	Schussler raises Pilarcitos Dam to 95 feet
1875	Spring Valley Water Company buys Calaveras land and water rights
1875	San Francisco offers to buy out Spring Valley Water Company
1876	Upper Crystal Springs Dam constructed
1877	San Francisco offer of $11 million to buy out Spring Valley declined
1880	Newly adopted State Constitution allows Board of Supervisors to fix water rates for San Francisco
1882 May	J.P. Dart, San Francisco and Tuolumne Company, proposes Tuolumne water for San Francisco
1888	George Harris offers Tuolumne water rights to Mayor E.P. Bond for $200,000
1888	Schussler completes Crystal Springs Dam and first outlet gate tower
1891	John Quinton surveys Hetch Hetchy and Tuolumne as potential San Francisco water source
1891	Schussler raises Crystal Springs Dam parapet — builds second outlet gate tower
1898	Use of Lock's Creek Line aqueduct discontinued — drilling starts at Pleasanton Well Field
1899-1900	USGS annual report recommends Hetch Hetchy for San Francisco water supply
1900 Jan 8	New City Charter requires development of municipal water supply
1900	Sunol aqueduct and Filter Beds completed
1901 Aug 12	City Engineer Grunsky recommends Tuolumne after studying 14 possible water systems
1901 Feb 15	Congress permits Interior Secretary to grant rights-of-way through Yosemite and other parks
1901 July 29	As private citizen, Mayor Phelan files for water rights
1901 Oct 15	Phelan applies to Interior Secretary for reservoir sites at Hetch Hetchy and Lake Eleanor
1902	Eugene Schmitz becomes Mayor of of San Francisco
1903	Spring Valley Water Company buys out by Spring Valley Water Works
1903 Feb 20	Phelan assigns all Hetch Hetchy water interests to San Francisco
1903 June 20	Interior Secretary Hitchcock denies San Francisco's first application to develop Hetch Hetchy
1906	Board of Supervisors adopts resolution #6949 formally abandoning the Hetch Hetchy development
1906 Apr 18	San Francisco Earthquake disrupts Spring Valley water supply — City burns for three days
1906 May 26	A.W. von Schmidt dies at age 85
1907	U.S. Geographic Board declares name of San Andrés Valley to be San Andreas
1908 Apr 22	City Engineer Marsden Manson files duplicates of Phelan maps with Interior Secretary
1908 May 11	Interior Secretary Garfield gives limited permission for Hetch Hetchy and Lake Eleanor
1909	Hermann Schussler retires from Spring Valley Water
1909-1910	Diversion tunnel constructed at Eleanor damsite
1910	State Constitution changed — Railroad Commission to fix water rates
1910	San Francisco votes 20-1 for $45 million bond issue to build Hetch Hetchy system
1910 Feb 25	Interior Secretary Ballinger withdraws Hetch Hetchy from Garfield Permit
1910 Apr 13	City purchases Eleanor Basin lands and water rights for $400,000
1910 May 10	Interior Secretary requests War Secretary to appoint advisory board of Army Engineers
1910 May 18	Board of Army Engineers appointed
1911 Jun 22	City purchases Cherry Basin land and water rights for $600,000
1911	Fred. C. Herrmann appointed chief engineer of Spring Valley
1911	Crystal Springs Dam parapet raised four feet in height
1912 Jan 8	"Sunny Jim" Rolph becomes Mayor of San Francisco
1912 Jul 15	John Freeman publishes his "Freeman Plan" for Hetch Hetchy
1912 Sep 1	Mayor Rolph hires M.M. O'Shaughnessy as City Engineer
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SAN FRANCISCO WATER & POWER

A History
of the
Municipal
Water Department
and
Hetch Hetchy
System

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1887 – Spring Valley Water Works Board of Directors.

Preface

This 1985 update of the history of San Francisco's water and power supply systems is published by direction of the San Francisco Public Utilities Commission. The challenge required months of personal familiarization with the immense scope and complex mechanisms involved in delivering water to City and suburban water consumers. Hydroelectric power generation for municipal services and industry required no less an accounting.

Water flow is traced from household taps back to the sources: through the City Distribution System; up the pipelines and tunnels to the dams of Peninsula and Alameda Divisions; further into the trans-state aqueduct across the San Joaquin Valley to the Sierra Nevada; again up the system of pipelines, hydroelectric power plants and tunnels in the Mother Lode; and through the great dams and impound reservoirs on the Tuolomne, Cherry and Eleanor in the Sierra Nevada; to the watersheds of Mount Lyell in Yosemite National Park — the ultimate source of San Francisco's water and power resources.

Previous histories and descriptions of this unique water-power system usually started in the mountains, followed the downstream flow and culminated with descriptions of local water treatment and delivery to users.

The first seven decades of the municipal water supply story is about its creation, operation, development and maintenance by private enterprise — The Spring Valley Water Company. Mayor "Sunny Jim" Rolph purchased the fully developed, mature water works for San Francisco at a cost of $39,962,606.51 on March 3, 1930. Since then the City has operated and maintained the water works as the San Francisco Water Department.

The Hetch Hetchy System had its birth in the Raker Act of 1913 which granted water resource rights-of-way on the Tuolumne River in Yosemite National Park to San Francisco. The total system is the realization of a concept for an aqueduct from the Sierra Nevada watersheds which had been planned since the 1860's. A very busy 20 years of construction on the Hetch Hetchy dams and aqueducts resulted in Sierra Nevada water being delivered into the Water Department local distribution system by 1934. Integrating Hetch Hetchy and Water Department systems has provided San Francisco and neighboring communities with an unfailing year-round assured supply of pure potable water from secure sources.

As research developed this updating of the water and power story, it became apparent that a reasonable approach to the story would be a chronological narration — from the beginning or earliest dates, through the successive improvements and additions — with some treatment of the personalities involved or responsible — to a description of the total system as it exists today. Some of the current thinking and plans for improvement and future development is included.

This is the rationale and outline of this 1985 edition of San Francisco Water and Power — a departure from previous treatments of the subject, yet an extension of them. It offers an appreciation of the magnitude of the water and power systems, the people who conceived and developed the physical improvements and the time span to create the separate units, and later integrate the Hetch Hetchy System and the San Francisco Water Department into one coordinated public service enterprise working under the Public Utilities Commission.

WDH, January 1985

City Engineer, O'Shaughnessy and Staff

Prologue

The seed for San Francisco's municipal quest for drinking water was sown in 1769, when Don Gaspar de Portola and Jose Francisco Ortega reconnoitered the peninsula and discovered San Francisco Bay. Their tortuous trek was diaried by Padre Juan Crespi. The seed was watered in 1773, by the exploratory expedition of Fernando Rivera y Moncada and Padre Francisco Palou. Palou returned to the tip of the 50 mile long peninsula with Juan Batista de Anza in 1776, when they founded Presidio Pueblo, a military town, and Mission San Francisco. The area is favored with a mild, maritime climate, and the seed of the quest for water took root. But the site they selected is bounded on three sides by salt water of the Pacific Ocean and San Francisco Bay and lies in the center of a region geographically classified as semi-arid.

Unlike some of Spain's earlier colonies in the New World, the Alta California had never been the site of a highly developed indigenous civilization. No public works for the multitude existed — neither cities, roads, reservoirs nor aqueducts.

Casual local water sources were adequate for the Presidio Pueblo and Mission. The soldiers and their families took their water from Laguna del Presidio (Mountain Lake), Arroyo del Puerto (Lobos Creek) and several springs, including El Polin, near the encampment. The lake, creek and Polin spring continue to produce water, but like most water produced from urban sources today, it is not considered potable.

Anza located Mission San Francisco near an *ojo de agua,* or small stream, which he named Arroyo de los Dolores. Originating on the heights of Pechos de la Cocha (Breasts of the Indian Maid), now called Twin Peaks, the stream generally followed the line of 18th Street into Laguna de Manantial, or Lake Dolores, which emptied through Mission Creek into Mission Bay (China Basin), originally called Ensenada de los Llorones.

The Dolores lake and stream have long since been filled in and built over. A portion of Mission Creek and Bay can still be found between Berry and Channel Streets from 7th Street to China Basin. The name, Dolores, remains on the street fronting the Mission, on the Mission chapel, on a church built adjacent to the chapel much later, and on a nearby neighborhood park.

Under Spanish royal rule, the Presidio Pueblo and Mission shared the placid, uneventful life common to all settlements in the California province. Life was slow moving and confined to the Presidio Pueblo and Mission grounds. Visits by Spain's galleons brought old world luxuries and political instructions from Mexico. Spain kept Alta California isolated. Visits by foreigners were not encouraged.

Hetch-Hetchy Valley (left).

Floor of Hetch-Hetchy Valley.

In the Beginning . . .

When Spain's royal rule over Yerba Buena and California was ended in 1821, Mexico opened Mission lands to settlement with the Secularization Act of 1833. Longstanding isolation policies were broken down, relaxing economic and political barriers to foreign commerce. Trade ships, hide droghers and whalers, entering San Francisco Bay found anchorage at Yerba Buena Cove, just north of the Ferry Building, to be better than that at the Presidio anchorage favored by the Spanish galleons. Mexican Governor Figueroa established a trading post at Yerba Buena Cove and named William A. Richardson, an Englishman, as harbormaster.

A settlement grew at the Cove for commerce with, and service to, the visiting ships. The original trails which connected the Presidio Pueblo to the Mission and thence south were joined by additional tracks to the new Mexican pueblo growing on the Yerba Buena shore.

There wasn't much of a settlement yet in December 1835, when Richard Henry Dana, Jr., who later authored the great 1840 American classic "Two Years Before the Mast," was a 20-year-old crew member aboard the Boston hide drogher, *Alert,* lying at anchor in the Cove. Twenty-four years later he reminisced, "It was in the winter of 1835-6 that the ship Alert, in the prosecution of her voyage for hides on the remote and almost unknown coast of California, floated into the vast solitude of the Bay of San Francisco. Our anchorage was between a small island, called Yerba Buena, and a gravel beach in a little bight or cove of the same name, formed by two projecting points. Beyond, to the westward of the landing place, were dreary sand hills, with little grass to be seen, and a few trees, and beyond them higher hills, steep and barren, their sides gullied by the rains. Some five or six miles beyond the landing-place, to the right, was a ruinous presidio, and some three or four miles to the left was the Mission of Dolores, as ruinous as the presidio, almost deserted, with but few Indians attached to it, and but little property in cattle. Over a region far beyond our sight there were no other human habitations, except a shanty of rough boards, put up by a man years in advance of his time, named Richardson, who carried on a very small retail trade between the hide ships and the Indians. The next year Richardson built a one-story adobe house on the same spot, which was long afterwards know as the oldest house in the great city of San Francisco."

Richardson's 1836 pretentious one-story adobe was the Casa Grande. It stood near Clay Street and Grant Avenue until 1852. The Pueblo of Yerba Buena, a town government organized by 450 residents, was taken by the U.S.S. Portsmouth, commanded by Captain R.B. Montgomery, on July 9, 1846. Montgomery appointed his lieutenant, Washington Bartlett, who was bi-lingual, to be the first American Alcalde. Bartlett proclaimed the name of the Pueblo to be San Francisco.

Courtesy of S.F. Public Library

Spring Valley Water Company Maintenance Crew

San Francisco's search for increasing quantities of potable water attempted to keep pace with the rapid growth and development of that sleepy pueblo into a major world metropolis. No wonder the sudden birth and overnight development of this City sparked and prodded a dynamic municipal quest for ever new sources of drinking water — at least from the earliest days of Yankee settlement.

Within the two years, 1850-1852, San Francisco was entirely destroyed by fire six times, with staggering losses of property, and was as often rebuilt. By 1859, the City was solidly built of brick and stone with nearly 100,000 inhabitants having all the accomplishments of wealth and culture. They also had vivid, fresh memories of widespread conflagrations and never enough water for fire fighting.

But, during the somnolent days of Yerba Buena, after Dana's visit and before the Gold Rush, San Franciscans took their water from a few streams and springs and from wells. These sources were no longer adequate by 1849, so householders bought water by the barrel. Water peddlers competed in the streets with barrels in carts serving regular water routes. Some had barrels slung across the back of a donkey. A footnote in history identifies one such entrepreneur as Juan Miguel Aguirre who took water from several locations. During periods of scarcity, Senor Aguirre reportedly charged as much as one dollar in gold for a bucket of drinking water, his thriving business earning some $30 a day. In 1851, the Sausalito Water and Steam Tug Company was barging the precious fluid across the bay by tank steamer from springs on the Marin shore using some 65 water carts to supply San Francisco householders. That same year, the Mountain Lake Water Company was formed to bring water from Mountain Lake in the Presidio.

A.E. VON SCHMIDT AND THE FIRST WATER WORKS

After a two-year effort, the Mountain Lake Water Company ran out of money in 1853, and was granted the first of several time extensions to bring water from Mountain Lake. In 1856, the San Francisco City Water Works, popularly known as the Bensley Company, was franchised by San Francisco Order No. 46. The next year, Alexei Waldemar von Schmidt, chief engineer of the Bensley Company, dammed the mouth of Lobos Creek and brought two million gallons of water a day by flume and tunnel around Fort Point, through the Presidio and under Fort Mason, to the Black Point Pumping Station at the foot of Van Ness Avenue. The Lobos Creek water was then pumped through two sets of heavy double force pipes to the Francisco (elevation 135 feet) and Lombard (elevation 305 feet) reservoirs on the north slope of Russian Hill. These reservoirs remain in use today.

The U.S. Census of 1860 reported San Francisco's

population as 78,000. The forecast was for growth — agriculture was being developed in addition to gold and silver mining. Seeing opportunity in Bensley's endeavor, George H. Ensign obtained a water charter from the California Legislature in 1858 and organized the Spring Valley Water Works. He laid a few pipes from an intermittent spring arising on Mason Street, about 100 feet north of Washington Street and some 1,000 feet west of Portsmouth Square. That spring had been a source for Juan Aguirre and others who peddled water during the Gold Rush Days, but it never produced more than 5,000 gallons per day. It gave the neighborhood and Ensign's water works its name — Spring Valley. The spring is covered over today — but it continues to produce water beneath the foundations of the Cable Car Barn at Mason and Washington Streets.

Ensign's franchise from the Legislature in 1858 was to lay down pipes. Because the spring did not run more than 5,000 gallons per day, it was considered so insignificant that the usual provisions for supplying water free for all municipal purposes, were omitted, except for fire extinguishing.

Later, this omission resulted in years of litigation and was the cause of much indignation and bad feeling. There were 11 years of litigation, Spring Valley suing San Francisco for water charges for municipal purposes, until a new State Constitution was adopted in 1880, placing water rate fixing with the Board of Supervisors. Fixing the water rates was then an annual squabble within the Board of Supervisors until 1910 when the Constitution was again changed placing the State Railroad Commission in charge of fixing San Francisco's water rates.

Although von Schmidt was the chief engineer and a founder of the San Francisco City Water Works, he had a dispute with Bensley who refused to pay for a water meter he invented. Vowing to "get even," von Schmidt left the Bensley Company in 1860 to become chief engineer and a leading stockholder of the Spring Valley Water Works. He developed Ensign's franchise and took over the meager Islais Creek water supply of the Islais and Salinas Water Company which had built a small dam west of the old Mission Viaduct near Rock House Gulch (Glen Park Canyon). The Islais Creek water was flumed around the hillside to the old Brannan Street reservoir between 16th and 17th Streets.

Francisco Street Reservoir: General view of reservoir, looking East.

The upper limit for Bensley Company production from Lobos Creek was two million gallons per day. Spring Valley was Bensley's stiff competitor and strong rival from 1862, but initially its spring and creek production could come up with only 200,000 gallons per day.

Convinced the City needed more water than could be produced locally by the limited sources within San Francisco, von Schmidt turned the quest southward, to the San Mateo County lands excluded by San Francisco's 1856 consolidation of the City and County. He promised San Francisco that water from the peninsula would be delivered to the City.

PILARCITOS

Pilarcitos Creek reaches the Pacific at Half Moon Bay. The upper Pilarcitos tributary watershed is less than half a square mile, but the drainage is on the western slope of the coastline mountains with elevations reaching 1,875 feet. Having the highest average annual rainfall on the peninsula — 49 inches — Pilarcitos is the most productive of the peninsula reservoirs.

Von Schmidt started constructing the first unit, a small earth dam impounding 65 million gallons of water, across Pilarcitos Canyon 11 miles south of San Francisco. Tunnel #1 was driven through Cahill Ridge from Pilarcitos to San Mateo Creek in 1861 — a work considered a stupendous undertaking for those days. Constantly observed and reported on by the press, Spring Valley accelerated construction work during May and June. As von Schmidt had promised, on July 4, 1862 the first peninsula water arrived in the City via the tunnel and 32 miles of redwood flume. Pilarcitos water was initially sent to the Brannan Street reservoir. Spring Valley's Laguna Honda reservoir on Seventh Avenue which was still under construction was ready to receive water in August.

As early as 1863, a particularly dry year, this first Pilarcitos supply proved inadequate to San Francisco's needs. The City was using seven million gallons of water a day — one third of the daily supply coming from Lobos Creek and the rest from Pilarcitos.

Spring Valley finished building the first of its major distributing reservoirs in San Francisco, Laguna Honda Reservoir on Seventh Avenue at elevation 370 feet, in August 1865. Pilarcitos water was then delivered by flume and pipeline to Laguna Honda by gravity flow. The pipeline was destroyed by the 1906 earthquake and never replaced. Tunnel #1 remains in service now connecting with Tunnel #2 to take Pilarcitos' excess runoff through Cahill and Sawyer Ridges to San Andrés Reservoir.

THE HERMANN SCHUSSLER ERA

These were the milestones of San Francisco's epic quest for water setting the scene, when 21-year-old Hermann Schussler came to California from Zurich. Born in the village of Rastebe in the Grand Duchy of Oldenberg, Schussler spoke little English. But armed with study at the Universities of Karlsruhe and Zurich, and with some engineering experience in Switzerland, he rode in on horseback with a carpet bag for his personal belongings.

Calvin Brown, who succeeded von Schmidt as Spring Valley engineer, hired Schussler on October 8, 1864, and put him to work building the second, larger Pilarcitos main dam. In early 1865, Schussler started Tunnel #2 through Sawyer Ridge on the Pilarcitos conduit line.

Meanwhile, along with Laguna Honda on Seventh Avenue, Spring Valley had built reservoirs on Clay, Market and Buchanan Streets with a total capacity of 46 million gallons. The Bensley Company had the cream of the water business in San Francisco, but its supply to the City from the Lombard and Francisco reservoirs was unequal to the demand. Lobos Creek could supply two million gallons of water a day — no more.

In 1864, Bensley was faced with soil eroding into his Lobos Creek aqueduct. Muddy water was being delivered to his customers and he needed clear water to settle the turbidity. Where to get clear water? The problem was solved in an unusual manner — Bensley tapped a Spring Valley main and sold the blend to his customers!

The irregularity was discovered and gleefully exposed by the press with a good deal of facetious writing. The

Washington Square, July 4, 1862.

But what a glorious Fourth of July San Francisco had in 1862! — News of Union victories at Mechanicsville and Malvern Hill came in by the magic of telegraph — the bitter struggle at Chickahominy could go either way — President Lincoln had just signed legislation for a railroad from the Missouri to the Pacific — everybody knew that meant a bright future for the City, so 80,000 San Franciscans decided to celebrate.

The 4th of July was to see the start of Market Street Steam Railroad service to The Willows at 18th and Valencia Streets, "a respectable resort" with pleasant music and good beer. Music houses had a new song for sale, "Aunt Dinah's Quilting Party."

The SS Golden Gate unloaded a cargo of oranges from Acapulco wholesaling for $35 a thousand. The Peter Clinton, out of Glasgow, arrived with 554 casks of ale and 20 puncheons of fine Scotch whiskey.

A parade was organized, from Washington Square to the Metropolitan Theater on Montgomery Street. Orator Robert C. Rogers "twisted the tail" of the British Lion. W. H. Tiffany, well known for the feat, read the Declaration of Independence — and Frank Soule, poet of the day, read 184 lines of original verse.

Aside from their patriotic fervor, San Franciscans were also marking a major milestone in their municipal water supply. Spring Valley lived up to its promise to bring in water from far-off Pilarcitos in time for the 4th of July festivities. The water from San Mateo County arrived shortly after midnight, as duly noted in the five principal daily newspapers — the Alta California, Call, Herald, Bulletin and Journal. The waters of Pilarcitos Creek were brought in with a larger supply than the City previously had, and at a better elevation. San Francisco celebrated!

ridicule hastened the end of Bensley's company and von Schmidt saw the realization of his vow to "get even."

It was about this time that von Schmidt became convinced San Francisco would soon outgrow its water supply on the Peninsula. He left Spring Valley in 1864, revealing his plans to use Lake Tahoe as a water supply, though not necessarily for San Francisco. Spring Valley bought out Bensley's company, the San Francisco City Water Works, on February 13, 1865.

In May 1866, Schussler was named chief engineer of the entire Spring Valley Water Works. He completed the main Pilarcitos dam to a height of 70 feet in 1867. Constructed of dry rolled-fill, with a puddled clay core, it was then one of the world's highest earth dams, impounding 600 million gallons of water. Eight years later, Schussler raised the dam to 95 feet, with a 520 feet crest length and one billion gallons (1,840 acre feet) capacity. The dam underwent repairs years later, in 1972, and today it meets California's updated earthquake standards.

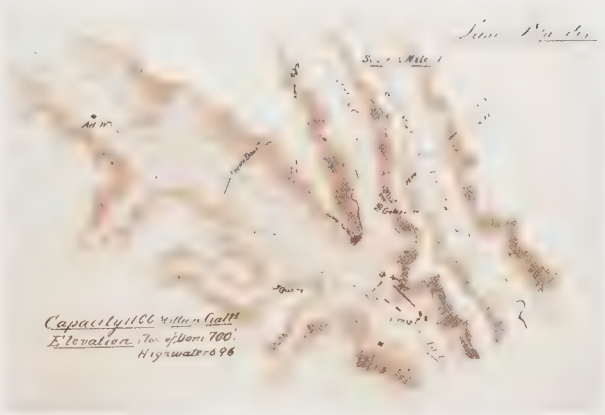
The Pilarcitos main dam project launched Schussler with Spring Valley. His career was to span a half century, leaving his mark for all time on the dams, reservoirs and aqueducts serving San Francisco in San Mateo, Santa Clara and Alameda Counties. The monumental water works spanning four counties, born of Schussler's genius, became the legacy of the San Francisco Water Department.

While making the survey for the Pilarcitos pipeline, Schussler noticed level ground in the San Andrés Valley and rerouted the pipeline to the higher ground towards Millbrae. He noted that for a distance of nearly three miles the valley raised only ten or fifteen feet.

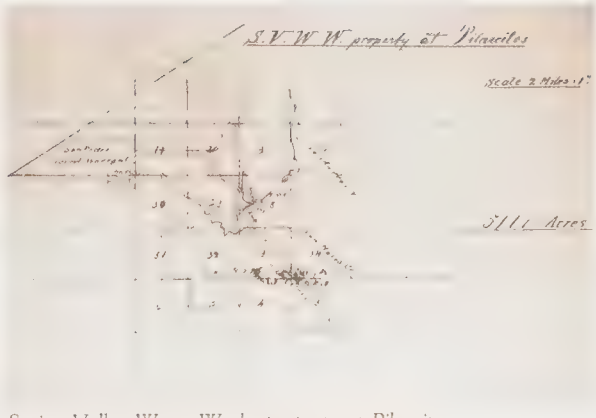
SAN ANDRÉS

As the daily demand for water gradually increased, Schussler's thoughts returned to the San Andrés Valley and he showed it to Spring Valley's executive board early in 1868. The board bought the valley and four or five square miles of the watershed. In April, Schussler started damming the San Andrés Valley and building its independent pipeline. In August, Spring Valley acquired rights at spring-fed Lake Merced in the City.

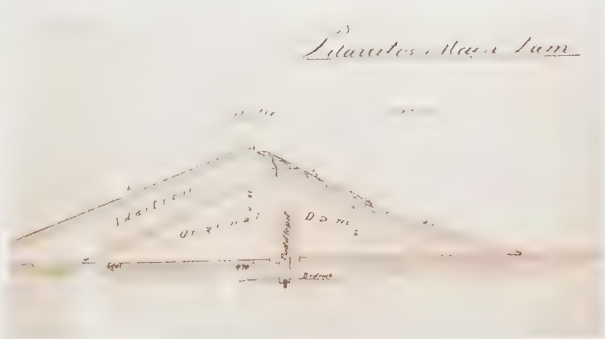
The great engineering feat of that day was driving a tunnel through Buri-Buri Ridge from the reservoir to the gulch north of Hillcrest Boulevard in Millbrae.



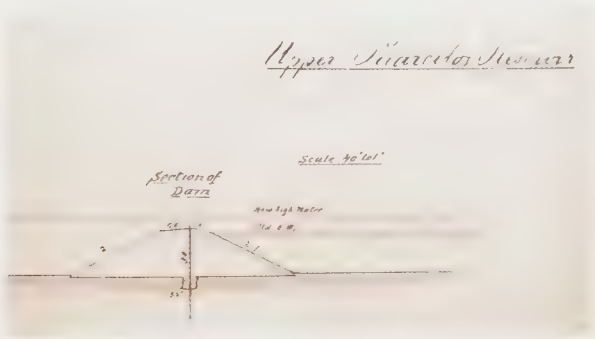
Lake Pilarcitos.



Spring Valley Water Works property at Pilarcitos.

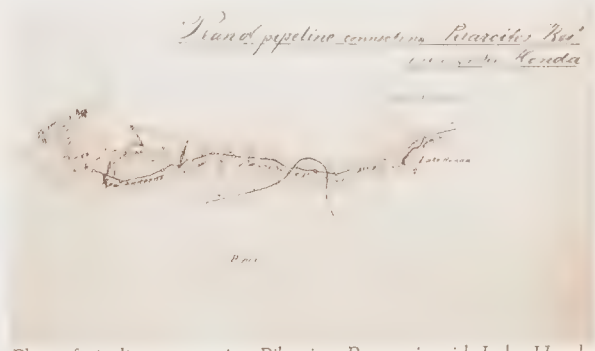


Pilarcitos Main Dam.

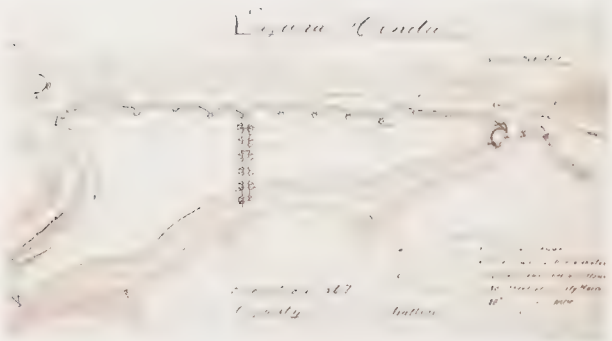


Upper Pilarcitos Reservoir.

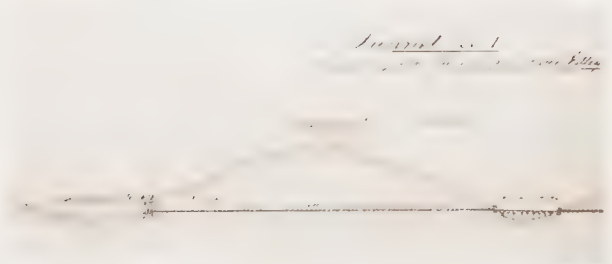
Pilarcitos Waste – Weir.



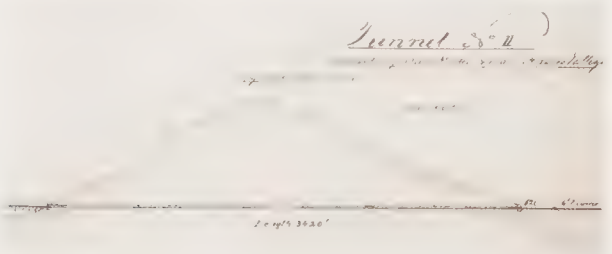
Plan of pipeline connecting Pilarcitos Reservoir with Lake Honda.



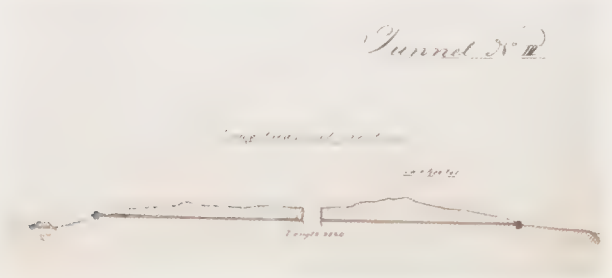
Laguna Honda.



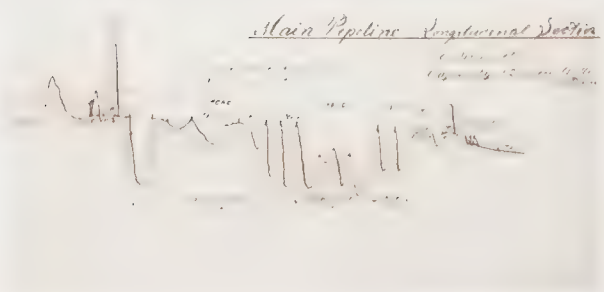
Tunnel #1 connecting Lake Pilarcitos with San Mateo Valley.



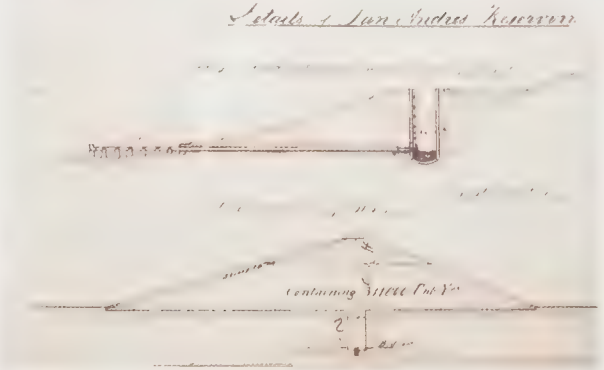
Tunnel #2 connecting San Mateo and San Andrés Valleys.



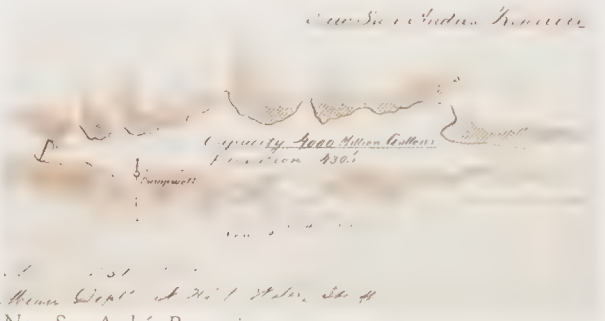
Tunnel #3.



Main Pipeline — Longitudinal Section.



Details of San Andrés Reservoir.



New San Andrés Reservoir.

The *San Francisco Alta* of November 26, 1870 said work started on both portals of the tunnel at the same time. Crews worked around the clock for ten months to complete it. The survey from the reservoir tunnel portal was made from the bottom of a 70 feet deep shaft. As the the two work faces of the 2800 foot long tunnel approached each other under the center of the hill, the betting was lively that the variation on meeting would be at least one foot. "On driving the two ends of the tunnel together in the center of the hill," the *Alta* boasted, "they struck inside of half an inch on the line and grade."

San Andrés Reservoir entered water operations for San Francisco in November 1870. From the Millbrae tunnel portal, the water entered a 30-inch pipe to College Hill Reservoir. There it connected with a 22-inch main that led to 25th and Valencia Streets, joining "the mesh-work of city pipes."

SAN ANDREAS

In the high valley just west of the Junipero Serra Freeway (I-280), San Andreas Reservoir is the first lake encountered south of San Francisco. A catchment and storage facility, it is on a branch of the San Mateo Creek, 2.5 miles north of Pilarcitos. Runoff is from some 4.4 square miles of watershed, supplemented by over 2.5 square miles of contributing areas, whose runoff waters are diverted into the reservoir by tunnels — Davis, Stone Dam #2, Pilarcitos #1 and #2 — through Sawyer Ridge from San Mateo Creek.

The dam was originally built and increased in height by Spring Valley's Hermann Schussler. In 1928 it was again increased to a height of 105 feet with a crest length of 950 feet, providing storage capacity for 6.19 billion gallons of water (19,000 acre feet).

The San Andreas Fault passes under the eastern abutment of the dam and although there was an eight-foot shearing movement along the rift during the 1906 earthquake, there was no damage to the dam.

There are three outlets from San Andreas. The south outlet (No. 1), was taken out of service in 1983 and plugged with 50 feet of concrete to eliminate any possibility of a destructive uncontrolled flow in the event of a severe earthquake or other disaster. North (No. 2), added in 1928, and center (No. 3) outlets serve as raw water sources for the San Andreas Filter Plant pump station which boosts the water to the filter plant. The plant serves the 54-inch San Andreas Pipeline No. 2 and/or the San Andreas Pipeline No. 3, which feed Sunset Reservoir. It can also supply high-pressure water to the Sunset Supply Line through its San Andreas Branch.

What's in a name? The etymology of "San Andreas" — A Bypath in History.

As the history of this Peninsula Division dam and its works north of Pilarcitos unfolds, its name changes from San Andrés to San Andreas.

When Spring Valley's Hermann Schussler built the works, the dam, pipeline, conduit, reservoir and lake were called San Andrés, after the valley.

That the valley was named San Andrés by the first Spaniards in Alta California is well documented in California history. Also Spring Valley records, Water Department files and Public Utilities Commission documents, up to some three decades ago, refer to San Andrés dam, conduit, pipeline, reservoir and lake.

With piqued curiosity, we pursued this mystery — the disappearance of San Andrés from historical record and the presence of an usurper, San Andreas, as the name of the valley and Spring Valley's works.

First thoughts were, that since Andrea is the feminine form of the Spanish Andrés, perhaps there had been a woman in history whom the Spaniards wanted to recognize. However, in Spanish grammar, Andrea is singular and Andreas is plural. If Spain's explorers had named this valley, as they did some of Alta California's geography, for a female saint, they would have used the feminine Santa Andrea and if for more than one Andrea — Santas Andreas. Something obviously is wrong. Although the church rota lists a Saint Andrew — San Andrés — we have no record of a Saint Andrea. Had there been a sainted Andrea, it is doubtful that the Spanish padres would have erred grammatically in her name.

So at what point or period in time did we substitute San Andreas for the San Andrés of old? And why did we call it San Andrés in the first place?

Padre Crespi's detailed log of Portola's reconnaissance of 1769 tells of Sergeant Juan Ortega being sent out with a party to establish landmarks. n Ortega's return, Portola turned inland on November 4, and crossing the hills north-eastward, the party went down into a canada, or valley, followed it south and then camped. Hubert Howe Bancroft, authoritative researcher of the Alta California early chronicles explains, "They have crossed the San Bruno hills from just above Point San Pedro to the head of the canada in a course due west from Millbrae." Bancroft continues, "Next day they march down the same canada, called by them San Francisco, now San Andrés and San Raimundo, for three leagues and a half, having the main ridge on the right, and on the left a line of low hills which obstruct their view of the bay.

Today that canada is the site of San Andreas Lake, Lower Crystal Springs Reservoir, Upper Crystal Springs Reservoir and San Andreas Canada south of the Pulgas Water Temple. The valley identifies the San Andreas Rift Zone on topographic maps.

Four years after Portola and Ortega, Fernando Rivera y Moncada and Francisco Palou went back along the same route and Bancroft says, "crossing the low hills into the canada that had been followed in 1769, to which, or to a locality in which, they gave the name Canada de San Andrés" on November 30, 1773, the feast day of the saint."

By 1776, the Canada de San Andrés was an established feature on Spanish maps. After founding the Presidio Pueblo and Mission San Francisco, Anza's route back to Monterey was through the Canada de San Andrés which he followed for six and a half leagues. He suggested establishing a second bay mission in the Canada de San Andrés, which would serve as a stopping place — escala — between Monterey and San Francisco. An escala was established as an outpost of the Mission San Francisco, but it was located in what is now downtown San Mateo.

There is strength and clarity in Hermann Schussler's writings and records. He constructed the dam, conduit and pipeline in the late 1860's, and was Spring Valley's Chief Engineer for fifty years. Spring Valley records and Schussler's logs are consistent in referring to the valley and water works as San Andrés.

Not so in the official county maps of the time. In its 1946 "California Place Names," the University of California Press cites the 1877 San Mateo County map as authority for claiming the Dam and Reservoir were San Andreas from the beginning, while acknowledging San Andrés as the name of the valley.

But there is an earlier San Mateo County map, that of 1868, which locates the Canada San Andrés and San Andrés at the location to be filled by the reservoir. The San Andrés Creek from the north, the San Mateo Creek from the northwest, and the Laguna Creek from Lake Raymundo to the south, came together at Crystal Springs, the former hotel resort, which was immediately upstream from today's Crystal Springs Dam.

Dr. Alan K. Brown of the San Mateo County Historical Association, in his 1975 "Place Names in San Mateo County," tells of San Andrés Creek (between San Andrés Lake and Lower Crystal Springs Lake), receiving ". . . its name from the valley at its head in Spanish times. The San Andrés Road up the creek was built in 1855 and named by around 1860. The southern part of the present road was opened in 1889, and is often called the Sawyer Camp Road, because it joins the old route at that point."

With regard to San Andrés Lake, Dr. Brown said, "The reservoir has been so called ever since it was created in 1868; it fills most of San Andrés Valley . . . The full Spanish form of the name was in at least as common use as the American translation down to 1880. The map spelling has been San Andreas, a common American corruption, since the 1850's, but the local spelling has never been really settled. The Spring Valley Water Company and, to some extent, its successor, the San Francisco Water Department, have always held out for San Andrés, and San Andrace has not been unknown. The United States Geographic Board declared for San Andreas twice, in 1907 and in 1931.

In his definitive "Sketch of the Geology of the San Francisco Peninsula," Andrew Cowper Lawson, Professor of Geology at the University of California, placed the name San Andreas, in 1893-1894, on the valley drained by the San Mateo Creek, on Spring Valley's dam, on the reservoir lake and on a creek which once shared headwaters with San Bruno Creek. Lawson incidentally located, but did not name, two geological faults along San Mateo and Pilarcitos Creeks. He would later identify the San Mateo Creek fault as the San Andreas Rift and the source of San Francisco's disastrous earthquake.

With professional and official acceptance of his paper, Lawson's status as the authority on geology of the San Francisco Peninsula was established. There is no challenge to his geological study here. Besides authoring the initial and definitive geology of the peninsula, which was entered into the Congressional Record, Professor Lawson guided University of California Geology studies. Generations of student geologists, seismologists and engineers learned of the San Andreas Rift, Valley, Dam and Reservoir — San Andrés fell by the wayside.

Within days following the 1906 Earthquake, Schussler invited Professor Charles Derleth, Jr., of UC's Civil Engineering Department, to examine the Spring Valley Water Works and earthquake repairs in progress. In May 1906, Derleth reported: "The waste-way conduit connecting it (Pilarcitos Reservoir) to San Andrés Lake is also intact." However, the professor made at least nine other references to the dam, conduit and pipeline, as San Andreas.

Later, California's Governor Pardee named Professor Lawson to chair the State Earthquake Investigation Committee. The Commission's report was published in May 1908. Lawson's introduction described the valley named in 1773 as the Canada of San Andrés. Lawson said, "The fissure (of the fault) follows an old line of seismic disturbance which extends . . . southerly obliquely across the Coast Ranges. . . . This line is marked by features due to former earth movements and will be referred to as a rift. . . . To distinguish it from other rifts . . . it will be referred to more specifically as the San Andreas Rift, the name being taken from the San Andreas Valley on the peninsula of San Francisco, where it exhibits a strongly pronounced character. . ."

Andreas is a well known name, quite familiar in 19th century California history. San Andreas is the Amador town identified with San Andreas Ravine, named by Mexican miners in 1848. There was also an Indian chief of the Chowhilla tribe near Riverside who carried the Mexican name "Captain Andreas." Lawson used San Andreas instead of San Andrés, the historical name of the valley. So in 1908, Lawson confirmed his own 1894 report naming the valley. San Andreas became dogma for successive generations of geologists and seismologists, and a popular topic for books and periodicals.

San Andrés remained on Spring Valley, Water Department and Public Utilities Commission records for the next four decades — but it was a losing battle. In government and popularly, the earthquake fault was the San Andreas. Spring Valley continued to use San Andrés for the dam and its works. But when the Water Department took over Spring Valley operations in 1930, San Andrés Valley works were, more and more, called San Andreas. The notoriety of the San Andreas Fault, the source of San Francisco's Earthquake, pushed aside the San Andrés name. San Andrés and San Andreas were used interchangeably — which concerned those charged with keeping the record straight.

"It was just over thirty years ago," recalls Ed Fonseca, San Francisco's watermaster and manager of the Suburban Division, "that we saw more and more miscalling of the dam and related works. Sometimes it was San Andrés, but more often San Andreas."

Fonseca resolved the confusion practically singled handed. In 1951, he started encouraging the use of San Andreas to designate all Water Department Works named San Andrés.

Asked why he opted for San Andreas, Fonseca recalled, San Andreas as the name of the fault is accepted by state, federal and local authorities. The fault has received lots of publicity since 1906. It's on all maps of the area and it's world famous — San Andreas is more popular than San Andrés.

The Public Utilities Commission annual report for 1952-53, settled the matter without further discussion by labeling as San Andreas all facilities previously called San Andrés.

With one brief exception since then, reports, maps and other references to the dam, reservoir, conduit and pipeline have been to San Andreas. The one published exception is the Hetch Hetchy Water and Power Systems map drawn by Charles L. Reed in 1958. Revised in 1966, the map still locates the San Andrés Reservoir west of Millbrae.

Less than 15 years later, the dust has settled and there was no question of the name. At the dedication of the San Andreas Water Filtration Plant in 1972, the welcoming brochure identified only with San Andreas Lake and San Andreas Dam.

As best as can now be reconstructed from written record and living memory, this is the history of how Spanish San Andrés became San Andreas, a name probably of Mexican origin and certainly of dubious grammar.

STONE DAM

Immediately after San Andreas started service as an impounding reservoir for San Francisco, Schussler developed the riparian rights held on the western side of Montara Mountain. The 1,650 acres give rise to Pilarcitos, Lock's, Apanolio and Los Trancos creeks, all emptying into the Pacific Ocean at Half Moon Bay.

The most economical and effective plan was to use gravity flow and made the creeks tributary to the San Andreas Reservoir.

Stone Dam and Cottage.

Development began in June 1870, with a contract for drifting Lock's Creek Tunnel, now Stone Dam Tunnel #1, from Pilarcitos Creek through Cahill Ridge to San Mateo Creek. Flumes were constructed to take the water from Lock's, Apanolio and Corinda Los Trancos creeks to the tunnel. The Lock's Creek Line was the result and instead of flowing to the ocean, the water from these creeks was diverted to San Andreas Reservoir, about fifteen miles northeast.

Pilarcitos Creek rises on the eastern side of Montara Mountain and flows through a narrow gap in the range to the west reaching the ocean at Half Moon Bay. The upper Pilarcitos is intercepted by Pilarcitos Dam, but the watershed below the dam is also extremely productive.

To exploit this lower watershed, the Stone Dam diversion was placed at elevation 550 feet, in the deep narrow canyon about two miles south of the Pilarcitos Dam. A flume, 4,500 feet long, was built south from the dam to carry the lower Pilarcitos water to the Lock's Creek Line Tunnel through which it was sent, along with Lock's Creek Line water to San Andreas. This work was done in 1871.

Stone Dam is constructed of rubble masonry, built of granite blocks quarried below the dam site, and topped with a brick coping laid herring-bone fashion. It is a thin arch dam, the pioneer example of this construction method. The small reservoir has a capacity of five million gallons (15.4 acre feet).

Lock's Creek development produced two million gallons of water per day. Its use was discontinued in 1898, but the Stone Dam diversion remains an integral part of the Peninsula Division system today.

Lower Pilarcitos flow is now diverted through the Stone Dam Tunnel #1 and concrete pipes to San Mateo Creek and Lower Crystal Springs Reservoir. The diversion of Lock's, Apanolio and Corinda Los Troncas creeks was abandoned around the turn of the century. The watershed rights on the west slopes of Montara Mountain were not part of the property San Francisco purchased from the Spring Valley Water Company.

CRYSTAL SPRINGS

The original terminus for the first Hetch Hetchy water to enter the San Francisco Peninsula, this beautiful lake is 13 miles south of San Francisco. Upper Crystal Springs

Lock's Creek Tunnel #1: Two miners drilling in the face of the tunnel.

Dam divides the lake three miles from the southern end. Built of earth with a puddled clay core in 1876, the dam is 520 feet long and 70 feet high, separating the upper and lower Crystal Springs lakes. The dam no longer retains water. Since 1923, it has supported the roadbed for the state highway to Half Moon Bay.

The first outlet for Upper Crystal Springs reservoir was a brick-lined, horseshoe shaped tunnel, six feet high, 5.5 feet wide and 775 feet long on the east side of the dam. A 90 feet deep, brick-lined shaft at mid tunnel gave access to a 42-inch regulating gate to control water from the reservoir.

In 1884, a 42-inch pipe was laid in the tunnel from the regulating gate beyond the outside portal of the outlet tunnel. To keep its crest above water and accommodate the relocated stage roadbed to Spanish Town (Half Moon Bay), Upper Crystal Springs Dam was raised in 1891 by an earth fill. The original outlet tunnel was broken during the 1906 earthquake, some 20 feet of the line fractured by a lateral earth movement of 5.5 feet. A 22-inch pipe was then laid through the concrete culvert at the west end of the dam to siphon water into the lower lake. The earthquake damage was ultimately repaired and on August 28, 1924 the original tunnel was restored to provide free, unregulated flow between the upper and lower reservoirs.

The newer Crystal Springs Dam on San Mateo Creek below the junction of its main branches, was built by

Stone Dam.

Schussler in 1888, raised a few feet in 1891, and again in 1911, to its present height of 154 feet. It is 176 feet thick at the base and 600 feet along the crest. A full gravity type, the arched dam is built up of interlocking concrete blocks formed and poured in place. The design permits a future increase in height of 45 feet. An excellent example of good concrete construction, the dam checks out to be as structurally sound today as on the day it was completed.

The dam showed no damage from the 1906 earthquake, although the faultline of the San Andreas Rift is only 400 feet west of the site.

The American Society of Civil Engineers designated Crystal Springs Dam as a California Historic Civil Engineering landmark in 1976. Spring Valley installed a bronze plaque at this dam commemorating the memory of Hermann Schussler, its builder, and translating the epitaph of Sir Christopher Wren in Saint Paul's Cathedral in London, "*Si Monumentum Requiris, Circumspice,*" applied it as Schussler's memorial: "If you seek his monument, look about you."

The Water Department continually inspects the dam and has conducted full scale investigations of safety aspects, looking into the geology and seismology of the area as well as analyzing the structure of the dam itself. Throughout the investigations, close liaison was maintained with the California Division of Safety of Dams. The conclusions reached in 1977 by three independent consultants, substantiate and confirm that this historic structure meets all current earthquake standards.

With a 35 square mile catchment area, the dam impounds 22.6 billion gallons of water (69,300 acre feet), forming a lake nine miles long, one mile wide at its widest and about 122 feet deep at its deepest. The lake has a surface area of 1483 acres and it covers portions of the early Spanish grant ranchos of Canada de Raymundo, de las Pulgas, Feliz and San Mateo.

Two outlet towers were constructed near the dam, one in 1891 and the other 40 years later. They are connected by gravity flow transmission mains, 17 miles long and mostly of 60-inch pipe, to University Mound Reservoir, and by another main, the 20-mile long Sunset Pipeline, of 78- and 60-inch diameter, through the Lake Merced Pumping Station to Sunset Reservoir. These pipelines are interconnected just below Crystal Springs Dam allowing supply to any transmission main.

Most Hetch Hetchy water, formerly delivered into Crystal Springs, now bypasses that reservoir via the Crystal Springs Bypass Tunnel coming off the Pulgas Portal Tunnel, and is routed through the Crystal Springs No. 1 and Sunset Supply pipelines into San Francisco reservoirs. Crystal Springs water is now sent by the Crystal

Springs Pumping Station, via a 60-inch pipe at the rate of 80 million gallons per day, to San Andreas Reservoir. San Andreas Water Filtration Plant processes this water and sends it on to the peninsula transmission mains for delivery to San Francisco and northern peninsula communities.

SUNOL FILTER BEDS AND PLEASANTON WELL FIELD

Concurrent with the start of Crystal Springs development on the Peninsula in 1875, Spring Valley turned attention to water sources across the bay. Land was bought in Calaveras Valley, fed by streams from Mount Hamilton. Spring Valley also acquired the Vallejo Mills properties near Niles, where a primitive water supply had been constructed years before by Don Jos2e de J. Vallejo, a brother of General Mariano Guadalupe Vallejo. This was the beginning of the Alameda Division.

Sunol Valley is a gravel filled depression of about 1,300 acres at the upper entrance to Niles Canyon in Alameda County. The entire Alameda Creek drainage of some 600 square miles flow through this area and is restrained at the canyon entrance. The Filter Beds were completed along with the Sunol Aqueduct in 1900. Sunol Dam, a concrete structure, 28 feet high, is usually submerged, but it holds back the creek flow to saturate the valley gravel beds. Through a concrete tunnel, or filter gallery, 8,985 feet long, pierced with screened brass pipes and tapped by 36-inch perforated concrete pipes, the water percolating through the gravel beds is collected. Dependable yield is five million gallons daily, but under flood conditions, the galleries will produce up to 20 million gallons of water per day.

The Sunol Filter Beds also receive water from Spring Valley's extensive artesian lands in the 35 square mile Livermore Valley, a natural basin area tapped by 100 wells into the deep gravel bed which ranges in depth from 200 to 734 feet. Spring Valley's Chief Engineer Schussler decided that these gravel beds, like those of Sunol Valley, were good water sources. He started drilling the wells in 1898. In 1909 a 30-inch pipe was installed to collect the well water.

Spring Valley later drew the water table of the Livermore Valley to an undesirably low level. At first, the Water Department suspended using the wells. Since 1949, pursuant to a formal agreement, no water is diverted from the valley. But water is pumped for local use.

Sunol Valley water is still collected and may be pumped to San Antonio Reservoir or the Sunol Valley Filter Plant. Most is directed to the Niles Aqueduct and then released to Alameda Creek. Emergency supply may be drawn from Niles Aqueduct to the Bay Division pipelines through the Irvington Pump Station and Niles-Irvington Pipeline. The Department hopes to restore the water table level so that the wells will someday be again available, but only for emergency use.

Hermann Schussler retired from Spring Valley as Chief Engineer in 1909. He remained in private practice until his death in 1919.

Fred C. Herrman was appointed Chief Engineer of Spring Valley in 1911. He relinquished the position in 1914, engaging in general practice as a consulting engineer and rendering valuable service to Spring Valley during the Rate Case of 1915-1917.

George A. Elliott was appointed Chief Engineer in 1914. He remained in that position until the municipal take-over of Spring Valley on March 3, 1930.

CALAVERAS

In 1877, San Franciscans were still uneasy and questioning the adequacy of their water supply. Despite the increasing volumes of water being brought into the City by Spring Valley, there never was really enough, and memories were fresh of the numerous fires which had devastated the young City. The Board of Supervisors frequently used water rates, which they controlled, as election issues. Spring Valley owners, questioning the adequacy of these rates, showed human reluctance to invest capital for developing additional water sources. San Franciscans again started talking about building their own water system.

A special study committee, headed by city engineer T.R. Scowden, recommended on April 19, 1875, that San Francisco buy a Calaveras site, on a branch of Alameda Creek in Alameda and Santa Clara Counties, as the beginning of a future municipal water supply. The City was unable to act quickly and the Spring Valley company effectively blocked this threat of competition by promptly purchasing the land and water rights for itself.

Calaveras impounds water from a number of streams flowing down the gorges of the Coast Range in the general direction of Niles Canyon. Two of these streams, Smith and Isabel creeks, after circling Mount Hamilton, unite to form the Arroyo Hondo, which flows through Calaveras Valley.

Construction of the earth and rock fill type dam did not start for another 38 years, until 1913. A series of misfortunes and engineering errors culminated in a failure of the partially completed dam on March 24, 1918, when the upstream face of the dam sloughed off and the water gate tower collapsed. The engineering diagnosis was that the rock fill had been improperly compacted leaving voids in the bulk of the dam. San Francisco City Engineer Michael O'Shaughnessy, foreseeing Spring Valley's take-over by the City, turned his attention to the Calaveras construction. Unofficially, he kept "a watchful eye on this proposition so that the City will not inherit a 'gold brick' if it should take this property over."

As it turned out, Spring Valley heeded O'Shaughnessy's advice and, averted a great tragedy. The dam, a valuable addition to San Francisco's water supply, was completed in 1925. At 215 feet high, it was the highest earth fill dam in the world, impounding 31.56 billion gallons (96,850 acre feet). The lower portion is built up by hydraulic fill method and the upper part with a rolled clay core supported on either side by loosely dumped material containing a large proportion of rock. The dam was nevertheless strengthened by the Water Department in 1975 to meet current earthquake standards — a $1.6 million project of the 1972 water bond program.

The dam is 1,200 feet long and 1,500 feet wide at the base. The outlet tunnel has two branches — one into the Hetch Hetchy Aqueduct through the Sunol Filtration Plant via the 44-inch Calaveras pipeline — the other to an aerating basin with a capacity of 74 million gallons per day.

The first significant east bay addition to San Francisco's local water supply system, Calaveras has a watershed area of 101.28 square miles for Calaveras Creek and 38.2 square miles for Arroyo Hondo, or a total of 139.48 square miles, of which 16.79 square miles are in Alameda County and 127.69 square miles in Santa Clara County. Mount Hamilton is the highest peak in the area, rising 4,448 feet above sea level.

Creation of the San Francisco Water Department

Crystal Springs Dam: Easterly end of outlet tunnel, showing brick-work and large, heavy 44'' regulating gate.

Municipal efforts to buy out the Spring Valley Water Company had been a source of constant controversy from as early as 1873, when the first attempt to purchase it was turned down by the voters because the price was too high. The voters usually found the sale price offered by Spring Valley to be higher than they wanted to pay.

A half century of farsighted leadership by a succession of mayors and engineers finally paid off on March 3, 1930, when San Francisco purchased the Spring Valley Water Company for $39,962,606.51, creating the San Francisco Water Department under the Board of Public Works. Nelson A. Eckart, Hetch Hetchy Chief Assistant Engineer under City Engineer O'Shaughnessy, was named the first general manager and chief engineer of the newly acquired water works. This takeover of the 70-year-old private utility took place four years before Hetch Hetchy water was to reach the Pulgas Temple in San Mateo County and when Spring Valley system had the capability of supplying 65 million gallons of water per day, under normal rainfall conditions.

SAN ANTONIO

The latest addition to Alameda Division's water supply, San Antonio was completed by the Water Department in 1965 at a cost of $9.4 million, which included the dam, outlet works, spillway and other appurtenances. The dam is named for James H. Turner, former General Manager and Chief Engineer of the Water Department, General Manager and Chief Engineer of Hetch Hetchy, and General Manager of Public Utilities for San Francisco.

Originally sited by the Spring Valley Water Works in 1875 and mentioned in the 1912 Freeman Report to provide storage adjacent to the Hetch Hetchy Aqueduct, the reservoir is situated on La Costa (San Antonio) Creek, a tributary of Alameda Creek, about three miles southeast of Sunol. The reservoir impounds 16.5 billion gallons of water (50,500 acre feet), the runoff from a 40-square mile watershed yielding over 1.8 billion gallons of water annually. Terminal storage for water from Hetch Hetchy and other sources also assures water service during possible

interruption of the Hetch Hetchy supply and meets high periodic demands in the South Bay Area.

Turner Dam is a compacted earth-fill structure 195 feet high, 2,160 feet long and 1,075 feet wide at the base. San Antonio water can be discharged directly to the Hetch Hetchy Aqueduct at Alameda Creek siphon through the Sunol Filtration Plant, or through the Sunol Filter Beds.

CITY DISTRIBUTION DIVISION

Having its origins in the first pipelines laid in 1857 by the San Francisco City Water Works (Bensley Company) from the Lombard and Francisco reservoirs and in the early system George Ensign installed at Spring Valley in 1858, San Francisco's complex water distibution system has grown over the past 125 years into a dozen reservoirs and auxiliary tanks at various elevations, pumping stations and an amazing network of 1,191 miles of pipeline, of various diameter, all tucked out of view under the City streets.

Built on hills, San Francisco's geography ranges in elevation from sea level to 900 feet. Totally urbanized, with homes at the highest elevations, the hills posed challenges and complicated hydraulic situations for water engineers. Their genius created a series of different pressure districts which incorporate the oldest water works, reservoirs and pipelines with the newest Water Department additions and improvements into a modern and efficient, integrated water distribution service.

Local water produced from Bay Area sources by the Water Department and Hetch Hetchy water from the high Sierra is delivered into the City, mostly by gravity flow, through four Peninsula transmission mains, San Andreas No. 2, Crystal Springs No. 2, Sunset Supply and Baden-Merced, each discharging into one or more of four terminal distribution reservoirs. From these reservoirs, the water is gravity fed, or hydropneumatically force-pumped, into eight covered distribution reservoirs, at elevations from 135 to 800 feet, and smaller storage tanks, strategically sited at elevations from 370 to 900 feet. The individual pressure districts being served vary greatly in area and can usually be supplied by more than one of these sources.

Construction of Calaveras Dam

San Francisco's twelve municipal reservoirs can hold, at capacity, some 414 million gallons (1,271 acre feet), about a five-day supply for the City. In addition, there is an emergency supply immediately available within the City at Lake Merced which holds 2.5 billion gallons (7,872 acre feet). In order of their size, the reservoirs ranked by their capacities in millions of gallons:

Lake Merced*	2,565.0
Sunset	174.8
University Mound	140.9
Balboa North Basin**	75.0
Sutro	31.4
Summit	14.0
College Hill	14.1
Stanford Heights	12.9
Merced Manor	9.5
McLaren Park Tanks	8.0
Lombard	3.3
Francisco*	2.5
Hunter's Point	1.1
Potrero	1.0

The underground transmission and distribution mains, ranging in size from 2-inch to 60-inch diameter are maintained and operated by the City Distribution Division. Water delivery is monitored to 163,000 services, some of which require as many as a dozen water meters. Along with the ongoing program of repair and annual replacement of 20,000 feet of deteriorated pipes, worn meters are replaced at the rate of some 4,000 per year.

*Emergency
**Future

WATER QUALITY DIVISION

San Francisco water supply is kept clean and clear, even during times of heavy rainfall and ground erosion, because a great deal of effort is expended throughout the water supply system by the skilled professionals of the Water Quality Division.

Now housed in modern facilities in the new $3.2 million Suburban Division Headquarters building in Millbrae, the Water Quality Division laboratories control water quality and treatment, meeting increasingly rigid state and federally prescribed safeguards and being regularly monitored by the State Health Department.

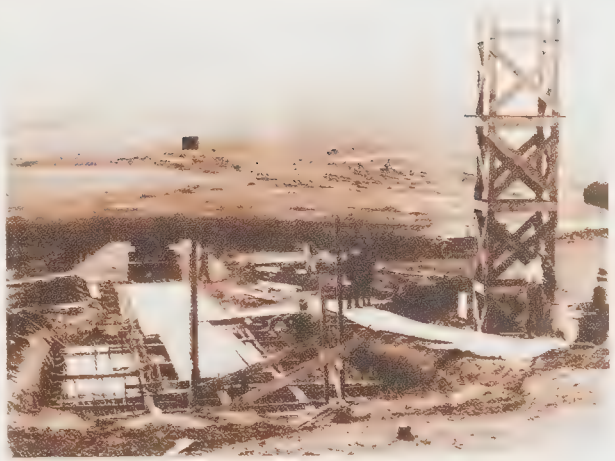
The Division's own goals and standards are exceedingly high — no water borne disease has ever been traced to Water Department supply in the Bay Area or Hetch Hetchy supply in the high Sierra.

All of San Francisco's water sources have been professionally and officially acknowledged as being relatively free from pollution. There is an initial mild chlorination for insurance. Hetch Hetchy sources in the Sierra Nevada were initially relatively secure from sources of contamination. Increased recreational use of the watersheds by equestrians, hikers and backpackers now require strict sanitary controls to be enforced throughout these areas.

The system wide sampling and testing responsibilities of the Water Quality Division range from Hetch Hetchy's highest elevations to the complexities of the City Distribution System. Water Quality staff members operate stations along the aqueduct and distribution lines for lime treatment, fluoridation and chlorination. Treatment at Rock River Treatment Plant adds magnesium (Mg) and lime or calcium oxide (CaO) to the "too soft" Hetch Hetchy water. The calcium oxide is slaked by water to form calcium hydroxide (Ca(OH)2) in the reaction CaO + H20 = Ca(OH)2, resulting in less aggressive water, slightly alkaline on the pH scale and inhibited in its corrosive action on pipelines, storage tanks, and the household plumbing.

A chlorine treatment is also used at the Tesla Portal of the Coast Range tunnel to assure safe water and check algae growth in the tunnel. Automatic chlorination takes place wherever water passes through a reservoir.

Waters delivered to San Francisco and consumers north of Crystal Springs have been fluoridated since 1952, in accordance with a program mandated by the voters in 1951. Results are a significant reduction in the incidence of dental decay for San Francisco children.



Stanford Heights Reservoir under construction looking towards Twin Peaks.

Merced Manor expanding under W.P.A.

SUNOL FILTRATION PLANT

Activated at its dedication on September 14, 1966 by Mayor John F. Shelley, Governor "Pat" Brown and Interior Secretary Stewart Udall, this plant was the Water Department's first filtration installation resulting from the nation's drive for clean water.

Constructed at a final cost of $10.5 million, the plant filters waters from Calaveras Reservoir, five miles south, San Antonio Reservoir, to the north, the nearby Sunol underground sources, and it has the recently added capability of filtering up to 80 MGD from the Hetch Hetchy Aqueduct.

The plant's original design capacity of 80 MGD was expanded in 1976 to 160 MGD.

The filtration plant was financed from Water Department revenues which service the $115 million water system bond issue approved by San Francisco voters in 1961.

SAN ANDREAS FILTRATION PLANT

This is a key element in the Water Department's peninsula supply system, filtering water from San Andreas Reservoir for delivery to consumers on the northern end of the San Francisco Peninsula. The 80 million gallon per day capacity plant started operation on August 8, 1972, and was built at a cost of $7.6 million.

Together with the Sunol Valley Filtration Plant in Alameda County, this plant provides the Water Department with the ability to supply pure, clear water from all five local impoundment reservoirs in the Bay Area to be supplemented by the supply coming through the Hetch Hetchy Aqueduct from the Sierra Nevada.

WATER QUALITY TREATMENT PROCESSES

Water produced from the local watersheds of the Peninsula and Alameda Divisions is treated by the Sunol and San Andreas Filtration Plants with processes of flash mixing, pH adjustment, flocculation, sedimentation, filtration and final disinfection.

As water enters the plants, several chemicals essential to the treatment process are added in proportion to the flow and thoroughly flash mixed. These chemicals include chlorine for disinfection, alum or polyelectrolite coagulant for turbidity removal, activated carbon for taste and odor removal, liquid fluoride to aid in the control of tooth decay, and coagulant aids, as necessary, to assist in the flocculation process.

The alum or polyelectrolite added in the flash mixing forms a white mineral precipitate coagulating into snowflake like particles called floc. As the floc is stirred, it traps tiny particles of silt, clay, bacteria and other foreign matter. Coagulant aids are added to assist the formation of strong, heavy floc particles which settle out quickly during the sedimentation process.

Sedimentation tanks accept water directly from the flocculation tanks. The water remains in sedimentation from at least one, to two plus hours. This is where the floc particles settle to the bottom, carrying with them any impurities. Sediment is removed from the tanks by a scraper into trenches and, in the case of Sunol, directed to setting basins or sludge basins, or in the case of San Andreas, safely pumped back into San Andreas Lake where it settles harmlessly to the bottom.

From sedimentation tanks, settled water moves to filters where it flows down through a bed of graded anthracite coal underlain by a bed of fine sand. The filters remove the last particles of sediment and foreign matter, producing a sparkling clear water free of turbidity and bacteria. Before they start to clog and lose efficiency, filters are automatically flushed clean of trapped material by backwashing with clean water.

The final step in the treatment is a controlled dosage of chlorine just sufficient to insure absolute safety of the water for home use. At the same time, a tiny amount of caustic soda is added to make the water less corrosive to metal pipelines and home plumbing. Final chemical additions insure the water will be delivered to home consumers with the same high quality it has when it leaves the filtration plant.

Mayor James D. Phelan.

Hetch Hetchy Water and Power

THE SIERRA NEVADA

When A.W. von Schmidt left the Spring Valley Water Works in 1864, he went on to general civil engineering practice, his most notable achievement in San Francisco being the successful destruction, under federal government contract, of Blossom Rock, a navigation hazard in the Bay some one-half mile northeast of Pier 39. A later and lesser known enterprise was von Schmidt's effort to tap the Sierra Nevada watersheds, not so much for San Francisco, although the City would have benefited from von Schmidt's success, but rather to irrigate both the Nevada desert and the California valley. Achieving only limited success and later forming the Bay Cities Water Company to exploit the Sacramento and American Rivers, von Schmidt blazed a trail to the Sierra Nevada for others who later looked to the mountains for San Francisco's water.

In May 1882, J.P. Dart, engineer for the San Francisco and Tuolumne Water Company in Sonora County proposed a route for bringing water from the Tuolumne, upstream from Jacksonville, to San Francisco. In 1888, George M. Harris pointed out the possibility of Hetch Hetchy Valley and Tuolumne River water supply to Mayor E.P. Bond, offering to sell his rights to the entire length of the Tuolumne for $200,000. John Henry Quinton, a Los Angeles engineer, investigated Hetch Hetchy and the Tuolumne, reporting to the U.S. Geological Survey in 1891. The U.S. Geological Survey annual report, 1899-1900, included a study recommending Hetch Hetchy as an adequate water source for San Francisco.

These were some of the numerous investigations and studies into additional sources of clean drinking water for San Francisco. Farsighted civic leaders began to realize that the only satisfactory solution to the problem was municipal ownership of assured water sources. However, Spring Valley Water Company owned or controlled all local Bay Area water sources as far away as the Coast Range in Alameda County. The decision was made — San Francisco must look beyond the Coast Range for a future water supply, to the Sierra Nevada along California's eastern border. This was no small concept — from the City it is 50 miles across the Coast Range, another 50 miles across the San Joaquin Valley, and still another 50 miles through the foothills to the Sierra Nevada proper — or just about 150 miles!

For a city with less than 350,000 population, supported by only a few scattered communities around the Bay, this was a tremendous challenge. The situation and task had to be met, if the City and Bay Region were to continue to grow.

Mayor James Phelan directed City Engineer Carl E. Grunsky to study 14 possible water sources during 1900 and 1901:

Spring Valley Water Works	San Joaquin River
Lake Tahoe	Clear Lake and Cache Creek
Yuba River	Stanislaus River
Feather River	Mokelumne River
American River	Tuolumne River
Sacramento River	Bay Shore Gravels
Eel River	Bay Cities Water Company

Grunsky's investigation established the superiority of the Tuolumne River system — later called Hetch Hetchy — for the following basic reasons:

Quality of the water
Largest amount of water available
Largest and finest reservoir sites
Freedom from conflicting legal claims
Hydro-electric power possibilities

Grunsky and Marsden Manson, who succeeded Grunsky as City Engineer, shared Mayor Phelan's enthusiasm for Hetch Hetchy. They knew, before the study was completed, that the Tuolumne had to be the answer to San Francisco's problem.

The Tuolumne, with its source in a perpetual glacier on 13,000 feet high Mount Lyell, drains 652 square miles of watershed in rugged granite mountains sloping west from the Sierra Nevada crest. Over 90% of the watershed is at elevations above 6,000 feet. In an unsurpassed natural setting, the Tuolumne flows through the northern reaches of Yosemite National Park and through the Stanislaus National Forest. The river emerges from the foothills into the valley near La Grange and merges with the north-flowing San Joaquin River some ten miles west of Modesto.

Having decided in 1901 that the best move for the City was to develop the Tuolumne watershed, the Mayor and city engineers, remembering Spring Valley's preemptive move in the Calaveras Valley in 1875, quietly and quickly put up their own money to send engineer J.P. Lippencott into the Sierra Nevada for the necessary surveys.

By the Act of February 15, 1901, Congress authorized the Secretary of Interior to use the rights-of-way through the Yosemite, Sequoia and General Grant National Parks for water conduits, water plants, dams and reservoirs.

On July 29, 1901, Mayor Phelan filed for water rights as a private citizen and on October 15, 1901, he applied for reservoir sites at Hetch Hetchy and Lake Eleanor. He assigned his interests to the City in 1903. Acting publicly in the City's name would have risked losing out to the private capital of speculators.

As Manson later put it, "If we had attempted an appropriation through the Board of Supervisors, the cat would have been out of the bag — so we paid the expense ourselves."

San Francisco's first application to develop Hetch Hetchy was denied by Interior Secretary E.A. Hitchcock on June 20, 1903, and the denial was reaffirmed on September 22. Hitchcock claimed the Secretary had no authority to to make the grant. It wasn't until 1906, that an earlier Attorney General's opinion came to light, advising the Secretary of Interior that he did, in fact, have such authority.

In early 1906, some 1,200 land owners in the Modesto and Turlock Irrigation Districts, claiming they feared for their rights to the Tuolumne water, petitioned the San Francisco Board of Supervisors to abandon the Hetch Hetchy project. The Board, controlled by Mayor Eugene E. Schmitz, who succeeded Mayor Phelan in 1902, promptly adopted resolution #6949 in February, formally abandoning Hetch Hetchy.

Enthusiastic Hetch Hetchy sponsors thought they were inured to road blocks, but they were unprepared for this one arising on the home front.

Then there was the devastating earthquake of April 18, 1906, and the failure of the Spring Valley water supply system to curtail widespread destruction by three days of fire following the great shake.

On June 21, the Board of Supervisors received 11 new proposals for water sources. Mayor Schmitz appointed a panel of engineers on July 30, to study the proposals. When the panel resigned without making a recommendation, rumors were that the engineers would not put their stamp of approval on the one source that was apparently favored by the Schmitz administration.

Recommendation or no, the Board of Supervisors Committee on Water Supply selected the Bay Cities Water Company proposal that the City buy its system for $10.5 million. Afterward, the Board asked the City Engineer to report on the Bay Cities property, which had genesis in von Schmidt's early investigations of the Sierra Nevada as a San Francisco water supply. Bay Cities depended on water from the south fork of the American River and the north fork of the Consumnes River.

This highhanded action was apparently the last straw for financier Rudolph Spreckels, *San Francisco Bulletin* editor Fremont Older, former Mayor Phelan and others. The Bay Cities deal was just another in a long series of corruptions, but it infuriated advocates of clean government and launched, in 1906, a series of investigations into graft and corruption, which came to trial in 1907 and 1908.

San Francisco's political boss, Abe Ruef, crony and benefactor to Mayor Schmitz, was sentenced to 14 years in the state penitentiary — he actually served five years in San Quentin. Mayor Schmitz, who had been a violinist and president of the Musicians' Union when Ruef gave him the political nod and blessing as Mayoral candidate, was also convicted and sentenced to five years, but the Mayor's conviction was reversed in appellate court. Before resigning, 16 members of the Board of Supervisors testified for the prosecution.

Rebuilding from earthquake damage, investigations and trials occupied San Francisco's time and energies, delaying development of the City's Hetch Hetchy interests. The campaign was in good hands. The old, dim memories of the City in flames because of lack of water were now refreshed and brought into vivid, sharp focus.

On April 22, 1908, Manson filed duplicates of the Phelan maps with Secretary Garfield just to be sure everything was in order. He signed these rights over to the City for one dollar.

With a convicted Mayor, the office devolved briefly upon Supervisor Charles Boxton, one of the 16 who later resigned. Boxton was followed in the Mayor's Office by Dr. Edward Robeson Taylor and Patrick Henry McCarthy. San Francisco was getting ready for James Rolph, Jr. to enter the scene in 1912.

The long hard fight to build a dam and related installations within Yosemite National Park was on. The Park was created by Congress on October 1, 1890, but at the time it did not include Yosemite Valley and Mariposa Grove. Congress had given them to California for park and recreation uses in the 1864 Yosemite and Big Tree Grants signed by President Lincoln. In 1906, the State ceded these properties back to the federal government and they were added to Yosemite.

On May 11, 1908, after holding hearings in San Francisco, Interior Secretary Garfield granted limited permission for reservoirs, dams, aqueducts and rights-of-way, with primary rights at Lake Eleanor and secondary rights at Hetch Hetchy. The Taylor Board of Supervisors ac-

J.R. Freeman, President of the American Society of Engineers.

John E. Raker.

cepted the Garfield Permit and a $600,000 bond issue was approved on the June 4, 1908 ballot to purchase lands in and around Lake Eleanor and Hetch Hetchy Valley. San Francisco voters then gave a 20 to 1 majority in 1910, to a $45 million bond issue to start construction of the Hetch Hetchy system.

The troubles began anew. Opposition cropped out from four major sources: the private Spring Valley Water Company, the Turlock and Modesto Irrigation Districts, power promoters, and the National Park Service supported by sentimental nature lovers. It required four years to satisfy the federal government in Washington that there were more reasons to justify San Francisco's application, than objections by opposing forces.

A new Interior Secretary, Richard A. Ballinger, took office in Washington. On February 25, 1910, he issued San Francisco an order to show cause why the section of the Garfield Permit applying to the Hetch Hetchy Valley should not be revoked. This would have left the City with development rights only in the Cherry Creek Canyon and Eleanor Creek areas, clearly insufficient for San Francisco's needs.

On May 10, 1910, the Secretary of Interior requested the Secretary of War to appoint a board of Army engineers to look into the Hetch Hetchy proposal. The eventual report of the board, on February 19, 1913, supported San Francisco's contention that the Hetch Hetchy Valley and reservoir site be retained in the permit. But it was now clear to all that a permit from the Secretary of the Interior would forever be subject to the whims of succeeding administrations. The only reasonable relief available to the City would be an outright grant of the necessary privileges from the Congress itself — enactment of a Hetch Hetchy Grant act.

The City hired John R. Freeman, a hydraulics engineer from Providence, Rhode Island, who was later to become an engineer for the New York Board of Water Supply. In 1912 he published a preliminary design for the Hetch Hetchy system, the Freeman Plan. It was largely responsible for the favorable findings by the board of Army engineers. Construction of the project was to follow Freeman's gravity concept and general format. Well known and internationally respected, Freeman was also a good advocate and defender of Hetch Hetchy.

THE RAKER ACT

Representative John Edward Raker of Manteca fired the first shot in Congress by introducing HR 112 on the floor on April 7, 1913. That bill could not be passed by the House, nor could the three compromise bills following: HR 4319 on April 25, HR 6281 on June 23, and HR 6914 on July 18. It was HR 7207, introduced on August 1, entitled "Hetch Hetchy Act," but popularly known as The Raker Act, that met the needs of San Francisco and overcame the objections of those opposing the Hetch Hetchy project.

The House adopted the Act on September 3, under the guiding leadership of Congressman William Kent. It was he who had purchased over 400 acres of redwoods in Marin County to save the trees from destruction, then giving the grove to the United States. In 1908, that grove became Muir Woods National Monument.

The battle for the Hetch Hetchy Act moved to the floor of the Senate. Debate on the Raker Act covers hundreds of pages in the Congressional Record. The Record also lists scores of letters, pro and con, from all parts of the nation. Newspapers from coast to coast took editorial stands for or against the proposed Hetch Hetchy development.

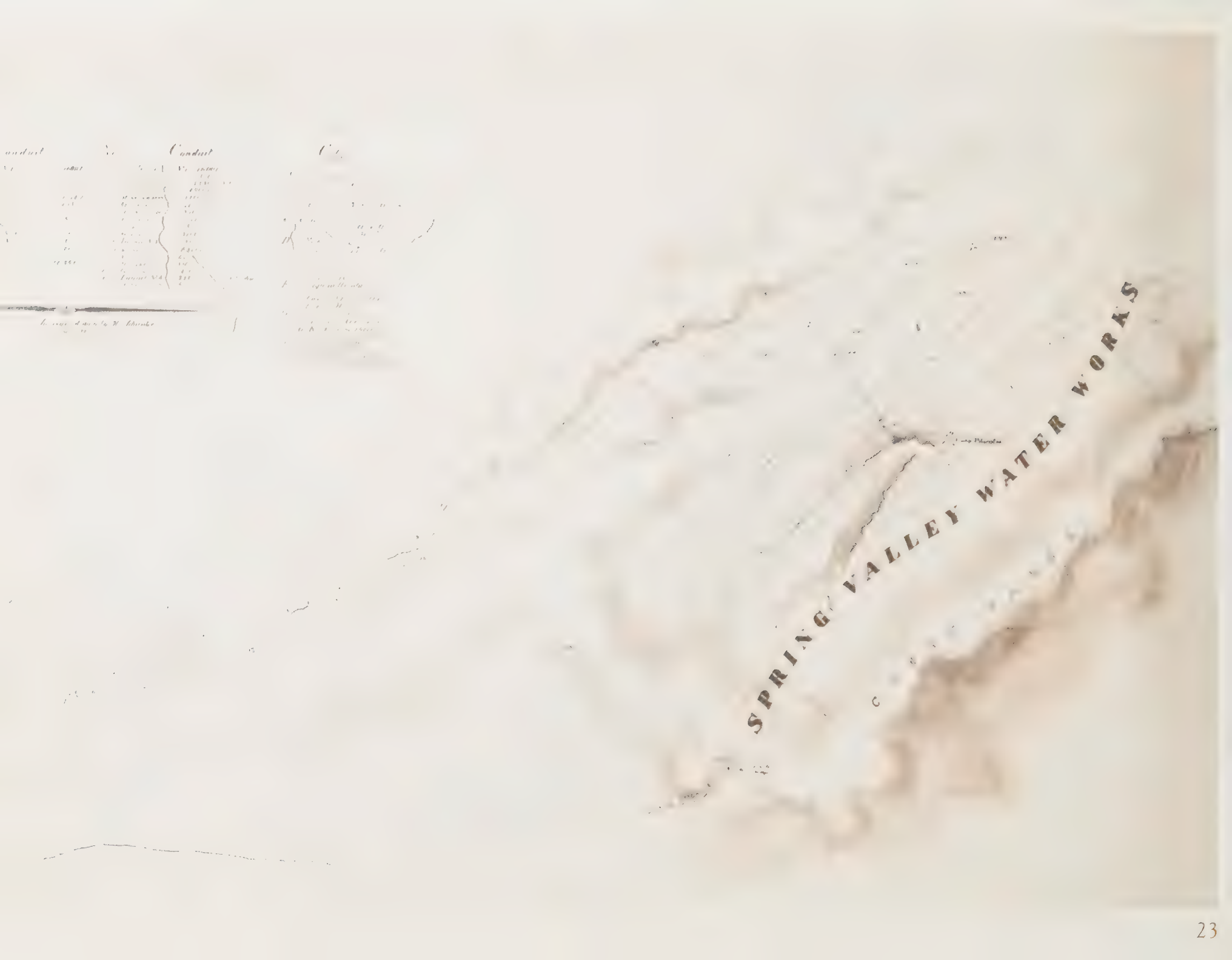
First the caucus rooms, then the floor of the Senate itself, became arenas for an extended and heated battle. Spring Valley and its agents made inflammatory claims and charges. San Francisco's plans were supported by the War Secretary's board of Army engineers.

Except for the Spring Valley Water Company, which fought to keep its monopoly of San Francisco's water, most of the opposition to the Hetch Hetchy plan came from states other than California. National interest was fanned by dire and ominous forecasts by environmentalists. A large photo of Wapuma Falls, with the caption "Will be Destroyed by the San Francisco Plan," was published by the weekly magazine, *New York Independent,* on October 30. A group claimed that Hetch Hetchy would ruin Yosemite Valley, 26 miles to the south, and that the Calaveras Big Trees would die of thirst, although they are over 30 miles away!

No less a personage than Senator William E. Borah claimed, in imposing oratory, that Hetch Hetchy would kill the potential of the San Joaquin Valley, if San Francisco were permitted to use the Tuolumne water.

Other viewpoints, however, were not so parochial or short-sighted. Ansel F. Hall published his "Handbook of Yosemite National Park" in 1921, while he was an information officer for the National Park Service. The chapter, "Geology of Yosemite National Park," was authored by University of California Geology and Mineralogy Professor Andrew C. Lawson, remembered for chairing the State Earthquake Investigation Commission and naming the San Andreas Rift Zone. Lawson described how glaciers scooped out the Hetch Hetchy Valley and, on receding, dropped glacial debris at the lower entrance to the valley forming a basin for a tarn, or mountain lake, which collected sediment from the melting ice above and built out the level valley floor. Lawson said, "The lake which will soon be created in Hetch Hetchy Valley by the dam at its outlet, now being built by the City of San Francisco, will be but a restoration on a larger scale of the lake which once existed there. The new lake will seem very natural in its mountain setting."


CITY OF SAN FRANCISCO


SPRING VALLEY WATER WORKS

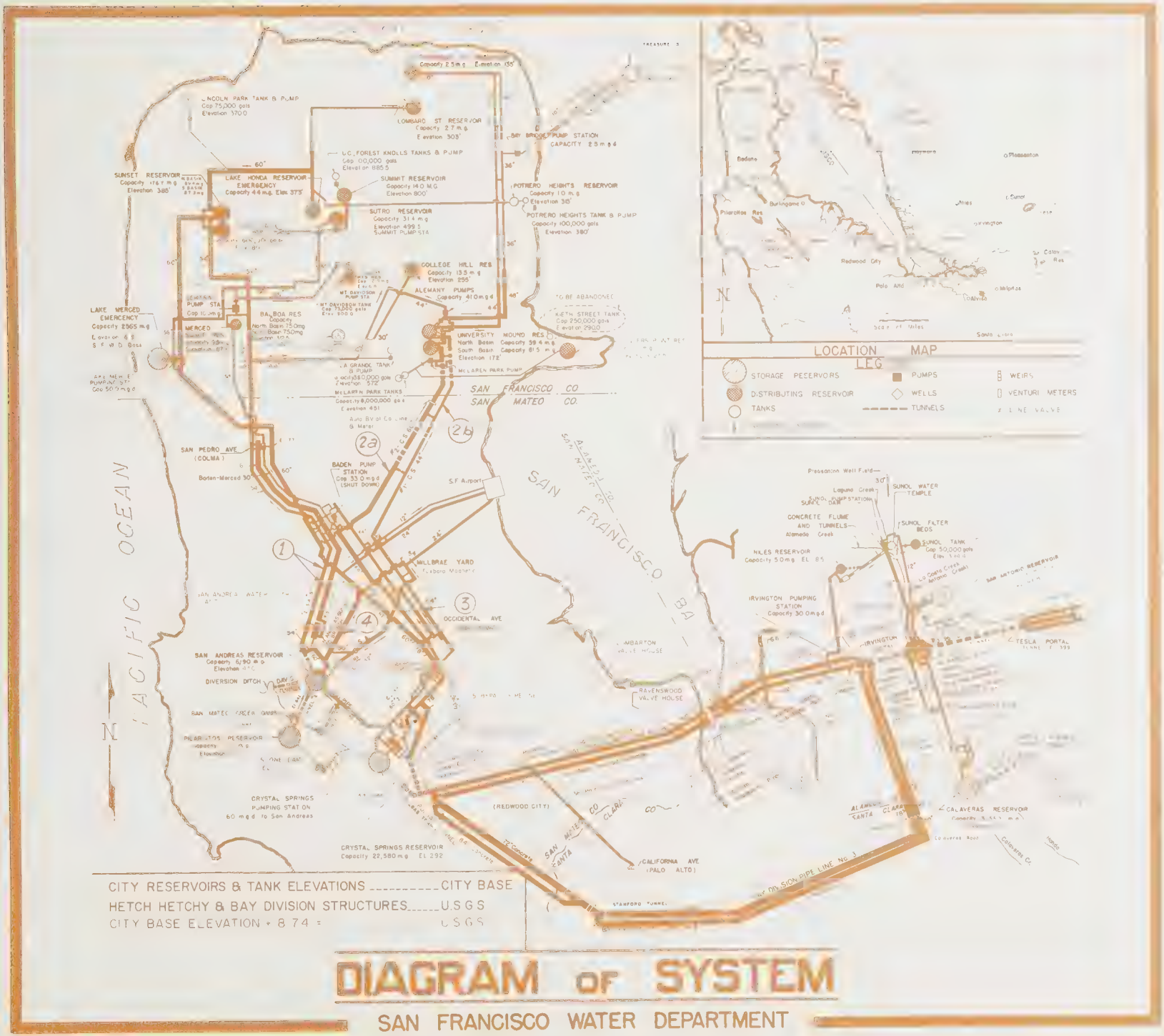


DIAGRAM OF SYSTEM

SAN FRANCISCO WATER DEPARTMENT


SAN FRANCISCO WATER
PACIFIC OCEAN
SAN FRANCISCO BAY
SAN FRANCISCO
LAKE HONDA RESERVOIR
SUNSET RESERVOIR
UNIVERSITY MOUND RESERVOIR
MERCED MANOR RESERVOIR
LAKE MERCED
SAN ANDREAS RESERVOIR
SAN ANDREAS DAM
PILARCITOS RESERVOIR
CRYSTAL SPRINGS BYPASS TUNNEL
PULGAS TEMPLE
REDWOOD CITY
BAY CROSSING
PALO ALTO
BAY DIVISION PIPELINE NO. 3 AND 4
HAYWARD
NILES
PIPELINE NO. 1 AND 2
NEWARK SUBSTATION PG&E
SUNOL FILTER PLANT
CALAVERAS RESERVOIR
SUNOL VALLEY WATER TEMPLE
SUNOL VALLEY TUNNEL
CALAVERAS DAM
LIVERMORE
U.S. A.E.C. LIVERMORE SITE
SAN JOAQUIN RIVER
TESLA PORTAL
VALVE HOUSE & CHLORINATION PLANT
SAN JOAQUIN PIPELINES NO. 1-2-3
STATION J
TUOLUMNE RIVER

CISCO WATER & POWER


MAP
OF THE
CITY AND COUNTY OF
SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
Pressure Districts
388 ft
Stanford
618 ft
800 ft
Potrero
Heights
380 ft.
Sutro
District
500 ft.
Merced
Manor
187 ft.
College
Hill
225 ft.

Other academia were of a different view. The presidents of Harvard University and Radcliffe College joined with their faculties and sent impassioned pleas to the Senate to "save Hetch Hetchy" from San Francisco.

However, San Francisco had never stood alone — support was widespread, coming from the California Legislature, every major California city, and all the neighboring communities of the Greater San Francisco Bay Area.

Pennsylvania's Governor Gifford Pinchot, a former National Forester and one of the nation's most respected environmentalists, provided significant support for San Francisco's cause.

In the Senate, the fight for Hetch Hetchy was led by such statesmen as Key Pittman of Nevada, George C. Perkins of California, George W. Norris of Nebraska, Charles S. Thomas of Colorado, Henry L. Myers of Montana, and William H. Thompson of Kansas.

But the clincher had to be the active support of William Randolph Hearst, editor and publisher of the *San Francisco Examiner* and head of a coast-to-coast chain of newspapers.

Hearst sent a special staff from the *Examiner* to Washington, D.C. On the morning of December 2, 1913, a 16-page Washington edition of the *Examiner* was published and placed on the desk of every Senator. On the front page were statements in support of Hetch Hetchy from the Vice President of the United States, Thomas R. Marshall, Secretary of State William Jennings Bryan, Secretary of the Interior Franklin K. Lane and Secretary of Agriculture David F. Houston. The historic *Examiner* also printed a telegram from the Modesto and Turlock Irrigation Districts advising of their joint meeting and decision to support San Francisco.

The heavyweight opposition to Hetch Hetchy vanished. Modesto and Turlock Irrigation Districts ended their opposition to the Raker Bill once they were assured their rights were protected and they would actually benefit from electric power surpluses. Opposition from Spring Valley Water Company subsided when a special clause was included in the Act providing that all of the water from sources near San Francisco be used, before water from the Tuolumne could be diverted. This clause protected Spring Valley in its investment in all properties and rights up to the full amount of their water producing capacity.

Even Spring Valley's President William Bourn decided that the handwriting was on the wall and the City was determined to prevail. His address to the Board of Supervisors on May 19, 1913, was later read to the Senate and entered into the Congressional Record, with telling effect. Bourn said, ". . . there is nothing as deplorable, there is nothing in my life that I regret as much as the water situation in San Francisco today. It is doing the City more harm than the earthquake ever did to it." He continued, "The City's object was opposed by the Spring Valley Water Company, the irrigationists of the Turlock — Modesto Irrigation Districts, the promoters of several water schemes which the City did not want, and by a small group of men who based their objections on a love of nature and opposed creation of a lake where a canyon now exists. All of this opposition, except that of the nature lovers, is withdrawn."

The Senate adopted the Raker Act during the night session of December 2, 1913.

No opposing voice spoke more fervently during the Congressional debates than John Muir, the famous naturalist and lover of the wilderness. Muir was an organizer and first president of the Sierra Club, serving in that position for 22 years following the club's founding in San Francisco, May 28, 1892.

It is a rare Sierra Club member who has not heard Muir's impassioned protest: "Dam Hetch Hetchy! As well dam for water tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man!"

Today, as then, John Muir is held in high esteem by the men and women of Hetch Hetchy. They share his love for the wilderness and his concerns for its preservation. To the present time, the name of John Muir is mentioned frequently in this beautiful and protected valley.

Today, as then, Hetch Hetchy people believe Muir was wrong — that a cruel fate indeed would have befallen Hetch Hetchy had the water supply project failed. For, at that time, the automobile was in its ascendency and it would have been only a matter of time before roads were built into the back country — perhaps in on the right and out on the left!

There is no doubt the Yosemite Valley, 26 miles to the south, is one of the crown jewels of Yosemite National Park inspired by John Muir. Often smoggy and reverberating from the noise of tens of thousands of daily visitors, it is hardly in tune with Muir's scheme of things. A General Plan, "for the beginning of a new era at Yosemite," has been undertaken by the National Park Service, to temper the impact of these thousands of visitors.

James "Sunny Jim" Rolph, Jr.

Hetch Hetchy waters, while sustaining millions of people in the San Francisco Bay Area, are no barrier keeping people away from the absolute stillness of the back country wilderness. Those willing to leave their autos, campers or motorcycles will find good hiking trails open from the trailhead at O'Shaughnessy Dam — the best of these trails were constructed and are maintained by the City and County of San Francisco.

The Raker Act has been criticized as a free gift to The City. The Act grants to San Francisco rights-of-way and public lands use in the areas concerned to construct, operate and maintain reservoirs, dams, conduits and other structures necessary or incidental to developing and using water and power. However, the Act imposes many conditions and obligations upon the City, stipulating, among others, that San Francisco was required to:

Recognize the prior rights of the Turlock and Modesto Irrigation Districts to receive water they can beneficially use, up to specified amounts of the natural daily flow, for direct use and storage.

Construct miles of scenic roads and trails in Yosemite National Park, and donate them to the United States.

Get started on the work of dam building at Hetch Hetchy and complete it as rapidly as possible.

Enforce specific sanitary regulations within the watershed area.

Develop electric power for municipal and commercial use.

Not divert beyond the limits of San Joaquin Valley any more of the watershed waters than is required for its own domestic or municipal purposes, excluding irrigation use.

Pay an annual rental starting at $15,000 and rising to $30,000 after 20 years.

Not sell or give Hetch Hetchy water or power to a private person or corporation for resale.

Congress pointedly disclaimed any intent to interfere with California State laws relating to the control or appropriation of water. This was of extreme importance to San Francisco, because the City holds water rights under California law — not the Raker Act.

The Raker Act, required the City to develop hydroelectric power which would be a natural by-product of the Hetch Hetchy water supply development.

According to the Interior Secretary, this would reduce fuel oil use in California. The federal government was strongly committed to a policy of conservation. Upon signing the Raker Act into law on December 6, 1913, President Woodrow Wilson said, ". . . it seems to serve the pressing public needs of the region better than they could be served in any other way, and yet did not impair the usefulness or materially detract from the beauty of the public domain."

Courtesy of S F Public Library

Michael "The Chief" O'Shaughnessy — City Engineer.

The Act was ratified by San Francisco in the Spring of 1914, and the Hetch Hetchy construction program started immediately.

Originally San Francisco sought a water source capable of adding 60 million gallons daily to the local supply. But on the advice of the board of Army engineers in 1913, the City shouldered a heavy load, assuming leadership for developing water resources to satisfy the entire San Francisco Bay Region until well into the 21st century.

Later, in the early 1920's, East Bay cities decided to develop their own supply from the Mokelumne River, leaving Hetch Hetchy to provide primarily for the need of the San Francisco Peninsula and the southern East Bay.

In Washington, members of Congress and President Wilson regarded the Raker Act as an excellent demonstration of the "conservation for use" policy. Advantages to the vast majority of the population and the general public welfare rendered any damage to the environment slight by comparison.

Though it was to flare up periodically during later years, the fight for the right to build the Hetch Hetchy Project was over.

O'SHAUGHNESSY AND HETCH HETCHY

San Francisco was still in the midst of one of history's greatest reconstruction projects, that of rebuilding the City ravaged by the earthquake and three-day fire of April 1906. Work on Hetch Hetchy began in earnest in 1914, eight years after that tragedy. The City was loaded with engineering talent of the highest order — city engineers and private consultants ready for any challenge that tested their imagination. Some of the finest engineers of the time "signed up" with San Francisco because they liked the concept of Hetch Hetchy and they respected "The Chief" — City Engineer Michael Maurice O'Shaughnessy.

The initial architects of Hetch Hetchy were City Engineer Carl E. Grunsky and his successor Marsden Manson. Grunsky directed the surveys that selected the Tuolumne River as the City's source and acquired some of its rights. Manson devoted his time almost exclusively to the project for twelve years, and continued his efforts even after he was out of office. In 1908, Manson had a survey party in the mountains under Drenzy Jones, a former Tuolumne County surveyor, with two San Francisco assistant city engineers, Leslie W. Stocker and Louis Mercado.

James Rolph, Jr., affectionately known as "Sunny Jim," assumed the office of Mayor on January 8, 1912. Less than nine months later, on September 1, he appointed O'Shaughnessy as City Engineer, with the caveat, ". . . you will answer only to me!" The peppery Irishman took the Mayor at his word. It is no accident that those who worked on the Hetch Hetchy Project referred to him as "The Chief."

With a Bachelor of Engineering degree from the Royal University of Dublin, Ireland, O'Shaughnessy had sailed around the Horn, arriving in San Francisco in 1885. Finding no employment in the City, his first jobs were designing a street system for Mill Valley and helping to raise Marin County's Alpine Dam. O'Shaughnessy was 48 years old and chief engineer of the Southern California Mountain Water Company in San Diego when Mayor Rolph summoned him to San Francisco.

The time was right for men like Rolph and O'Shaughnessy. Rolph was to become a dynamic and powerful chief executive, trusted and beloved by the people. He would serve as San Francisco's Mayor until he was elected Governor of California in 1931.

O'Shaughnessy was a first-rate engineer — his political perceptivity was unsurpassed. As the right hand of the masterful Rolph, O'Shaughnessy made the Hetch Hetchy Project move.

But where "Sunny Jim" was charming and gracious, and made every stranger his friend, "The Chief," although respected by those who worked for him, could become somewhat abrasive — a trait that was to give him trouble as the project neared completion.

There is no shortage of anecdotes about the colorful O'Shaughnessy — the man of action! On the long list of his many admirers we find, among others, the name of Jack London. Of those who sat through the Senate debate on the Raker Act, a significant number came primarily to see "The Chief" in action.

If there is a "secret" behind Hetch Hetchy's phenomenal construction success, it must be that one of the most talented groups of engineers ever to come together, did so as a working team. From the first days of construction, over seven decades ago, the Hetch Hetchy challenge attracted gifted engineers. That attraction, or should one say fascination, continues today.

Not only were there nearly impassible mountains and attendant engineering problems, there were other obstacles — a 75 percent increase in prices between 1913 and the World War I Armistice — attempts at political interference and foot-dragging on appropriations — but San Francisco had earned the sobriquet, "The City That Knows How," and Hetch Hetchy was built.

San Francisco now went back to the Freeman Plan. It was a preliminary project design, with detailed estimates, for ultimate development of a 400 million gallon per day producing system, and transporting that water to the Bay Area south and east of the City.

O'Shaughnessy sent his team, on foot and horseback, into the High Sierra for the final field surveys, while the City Engineer and his staff polished the Freeman Plan to add capacity to the project, ease the supply and construction problems, and, by work scheduling, lessen the expense to the taxpayers.

The resultant work plan was to build the dam at Hetch Hetchy initially to about three-quarters of its final height, developing about 60 percent of the reservoir capacity. The aqueduct from the mountains westward would be completed to Moccasin Creek and a powerhouse put in operation at that site as soon as possible. Another aqueduct section, 23 miles long, would be built in the Coast Range from Alameda Creek, south of Sunol in Alameda County, across the Bay to the Pulgas Portal in San Mateo County. This section of the aqueduct, the Bay Division, would be ready to carry Spring Valley water as their East Bay properties were developed, earning immediate income for the City. Later the Bay Division could carry Hetch Hetchy water as the system was built westward across the San Joaquin Valley. The remaining sections of the aqueduct were to have the Tuolumne waters ready for delivery when Spring Valley sources were used to capacity, but not before then, to minimize the financial burden on San Francisco.

Not only was the magnitude of the project vast in scope, involving dams, reservoirs, conduits, powerhouses and a 150-mile long aqueduct, but in the mountains, accessibility was a problem. It is a country difficult for mountain climbers, affording only few areas where horses can be maintained. Into this area, all manner of machinery and equipment had to be transported and thousands of workmen had to be accommodated and supplied.

Electrically driven drills were available to bore into granite, dynamite was a moving force, and the Hetch Hetchy Project engineers considered no area inaccessible to them.

O'Shaughnessy and crew.

GROVELAND

Before building the essential elements of the system, it was first necessary to get into the mountains with packers and guides, often using chartered stagecoaches and freight wagons out of Groveland, a small mountain town left over from the Gold Rush. It sits astride the Big Oak Flat road into Yosemite. With the coming of San Francisco's work forces into the area, Groveland was revitalized, booming for a decade as headquarters for the Hetch Hetchy Project. The quiet mountain village found itself suddenly with office and hospital buildings, homes for officials and their families, and shops and operating headquarters for a full scale railroad, bringing the first locomotives and cars that some of the Grovelanders had ever seen. Hetch Hetchy workers and equipment helped with extensive road improvements in the district. They improved the water supply and started a sewer system. They also resurveyed Groveland and nearby Big Oak Flat to correct inaccurate surveys made during the Gold Rush days.

CONSTRUCTION STARTS

The building of Hetch Hetchy is a fascinating saga, mainly due to its construction in segments. Separate, simultaneous, concurrent and consecutive contracts spanned work over the 150 miles between the High Sierra dam site and the Bay Area. Ultimately, these contracts and their work came together precisely. Dams and powerhouses in the high country, conduits and tunnels throughout the system, pipelines in the San Joaquin, and even across San Francisco Bay. That's how the project was built.

Preliminaries required careful planning. In this rugged and remote country of difficult access, major dams, powerhouses and tunnels were to be built. First priority had to be a reliable, high capacity form of transportation to move heavy machinery, bulk materials and supplies, and men into the mountains to the new dam site and other project auxiliaries. Clearly, a railroad was the answer.

May 3, 1922 — Round House Crew at Groveland.

Hetch Hetchy Dam — top of the Tramway.

HETCH HETCHY RAILROAD

So, San Francisco built the Hetch Hetchy Railroad! A 68-mile long, standard gauge railway, from Hetch Hetchy Junction — some 26 miles east of Oakdale — to the rim of the Hetch Hetchy valley. The minimum grade was four percent and the sharpest curve 30 degrees or a 190 feet radius. The highest elevation on the line is 5,064 feet at Poopenaut Pass. Built for some $3 million, it saved at least ten times its cost in cement hauling alone. It was completed in October 1917, and operated around the clock during the construction of the dam, using one rented locomotive and six of its own.

Hetch Hetchy Railroad operated as a common carrier from July 1918 to February 1925, under rules of the California Railroad Commission. It abided by "railroading practices," publishing time tables and tariffs. The freight rate base was 12.5¢ per ton mile for carload lots and the passenger fare base was 7.5¢ per mile.

But it was a different sort of railroad. Mayor Rolph was president of the line, Chief O'Shaughnessy was vice president and general manager. There was considerable informality in its operation — the management consisted of civil engineers, not locomotive engineers.

The railroad's purpose was to keep materials and supplies, primarily bulk cement, moving to the job site. It also carried the mail and provided passenger service. Weekend excursion groups of 40 to 100 San Franciscans would leave the City by Pullman sleeper Friday night, catching the Hetch Hetchy Saturday morning. Hetch Hetchy excursion trains took the groups to various camps to view the work, with meals and overnight accommodations being provided at bunkhouses. After two days in the mountains the groups were returned to their Pullmans Sunday evening and they arrived in San Francisco ready for work Monday morning. All this for a fare of about $30.

Most of the mountain construction work was completed by the mid-1920's, but the railroad was kept in use for another two decades — mostly for winter supply and maintenance while motor roads were snowbound. The tracks were removed in 1949, parts of the right-of-way were used by State Highway 120 in Big Oak Flat, and the Cherry Oil Road to Camp Mather and beyond to the O'Shaughnessy Dam. One of Hetch Hetchy's original six locomotives can still be seen at Yosemite National Park where it is on display.

THE SAWMILL

The mill was originally located in the National Park at Canyon Ranch, 4.5 miles from Hetch Hetchy. After six million board feet were sawn, the mill was moved in 1919 to Hog Ranch, some nine miles from the O'Shaughnessy Dam site. The operation was discontinued in 1924, after 21 million board feet of lumber had been cut. The mill was later dismantled and Hog Ranch is now San Francisco's summer recreation camp, Camp Mather, operated by the San Francisco Recreation and Park Commission.

LAKE ELEANOR AND EARLY INTAKE POWERHOUSE

Dam building requires a good, dependable source of electricity to run the boring drills, construction tools and other equipment. That meant a powerhouse as an early priority.

San Francisco built the tiny, Early Intake Powerhouse on the Tuolumne about 12 miles downstream from Hetch Hetchy. Construction started in August 1917, supervised by assistant chief engineer Nelson A. Eckert. Early Intake was equipped with three 1,500 horsepower Pelton-Francis turbines connected directly to three 2.3 kV, 1 kW generators. Rated the equivalent of 4,000 horsepower, 22 kV transmission lines carried the power 11 miles east to

August 14, 1919 – Hetch Hetchy Water Supply Dam receives $5,570,000.

the O'Shaughnessy Dam site, and 22 miles west to Moccasin. A two-mile line was take into Groveland and the Hetch Hetchy headquarters.

Water to assure continuous operation of the powerhouse came by damming Eleanor Creek to supplement the natural flow of Cherry Creek. This became the first dam of the Hetch Hetchy system. It was completed only ten months after the start of construction in August 1917, to a height of 70 feet, of multi-arch design, 1,260 feet long. Lake Eleanor was originally a typical shallow glacial lake. The dam turned it into a reservoir holding 28,000 acre feet.

A three-mile long system of flumes, pipes, tunnels and concrete lined canals — the Lower Cherry Creek Aqueduct — delivered the combined Cherry and Eleanor waters at 200 cubic feet per second to the hillside 345 feet above Early Intake Powerhouse. Electrical generation began in May 1918, and in 16 years the powerhouse produced $550,000 worth of power for Hetch Hetchy construction and $750,000 in cash revenues from commercial power sales. Early Intake continued to operate until 1967, adding its production to that of the Moccasin Powerhouse. Since 1960, water retained by Eleanor Dam is diverted through a mile-long tunnel to Lake Lloyd.

HETCH HETCHY SYSTEM DESIGN

San Francisco's original plan for Hetch Hetchy was to divert only 60 million gallons of water per day from the Tuolumne to serve the City's needs until well into the 21st century. On advice of the board of Army engineers in 1913, San Francisco found itself assuming leadership for providing the needs of the entire Bay Area, requiring ultimate development of the Tuolumne River to produce 400 million gallons per day. This was the amount necessary to supplement the local production capability of the existing Peninsula and Easy Bay sources of the Spring Valley Water Company, later to become the San Francisco Water Department.

The pressure on San Francisco to develop for the entire Bay Area was relieved in the early 1920's, however, when East Bay cities elected to find and develop their own water supply from the Mokelumne River.

Without undue strain, San Francisco was thereby able to meet the ever increasing requests for additional water from her own citizens and also from the mushrooming suburban areas and industrial complexes in a 50-mile radius south and east of the City.

The basic design of the Hetch Hetchy Project remains for a production capacity of 400 million gallons per day, although certain segments of the aqueduct currently have a lesser capacity. All of the work is so planned and designed, however, that none of the work will have to be done over. Additions can be made to various parts as the need arises without changing the basic design.

Early Intake Tramway.

Hetch Hetchy was built as economically as possible, but where additional work was necessary to eliminate future expense or unreasonable maintenance cost, that work was done. Succeeding years have amply demonstrated that the builders of Hetch Hetchy acted wisely.

The total initial cost of the Hetch Hetchy development — up to the first direct delivery of Tuolumne River water to San Francisco in 1934 — was just over $100 million. The cost was met solely by the City — without State or Federal assistance. At the price, San Francisco bought a bargain! This is what the package includes.

O'SHAUGHNESSY DAM AND HETCH HETCHY RESERVOIR

Preliminary work began in 1915 to create a reservoir collecting and storing the runoff from 459 square miles of rugged granite mountain watershed. The construction contract was awarded to Utah Construction on August 1, 1919, starting nearly four years of dam construction.

Built of cyclopean concrete, a process where about eight percent granite plums — blocks of stone ranging in size from one cubic foot to five or six cubic yards — are imbedded in plain concrete, the dam is of the arched gravity type. It has five vertical contraction joints, sealed by sheet copper strips, with inspection wells and ladderways at the contraction joints.

Initially 30 feet was considered an ample depth for the dam's foundation. But test boring of the ancient glacier's terminal moraine discovered that the retreating glacier had dropped untold tons of boulders, with intervening layers of sand, to depths of more than 90 feet below river level. At the downstream toe of the dam, bedrock was reached at 61 feet. But at the upstream toe, the glacial debris had to be removed to a depth of 101 feet.

Preliminary construction involved driving a 1,000 foot long diversion tunnel to carry the Tuolumne waters past the foundation excavation during dam construction. The tunnel is 23 feet wide and 25 feet high, through solid granite.

It took nearly four years of day and night operations, in all seasons, to pour the concrete brought in by the Hetch Hetchy Railroad, as much as 2,000 cubic yards in a day, the one-month record being 41,178 cubic yards. The dam was completed to its initial height of 226.5 feet, with a storage capability of 206,000 acre feet of water. At its dedication on July 7, 1923, it was acclaimed the largest single structure of the West Coast.

The dam was raised 85.5 feet in elevation fifteen years later, in 1938, and enlarged to 430 feet above bedrock, 900 feet crest length, 308 feet thick at the base, and impounding 360,000 acre feet of water.

Water from the reservoir can be released through 14 outlet conduits. Of these, 11 are regulated by manually operated valves ranging from three to six feet in diameter. The other three are connected to the Canyon Power Tunnel. The side channel type spillway has three drum gates, installed in 1950, providing additional storage

O'Shaughnessy Dam.

when the reservoir is full. Total cost of the dam, including its subsequent enlargement, was $12.6 million.

MOUNTAIN TUNNEL

At about the same time that preliminary work started on O'Shaughnessy Dam, the summer of 1917, City employees of the Hetch Hetchy Project started driving the Mountain Tunnel from Early Intake to Priest Reservoir above Moccasin. The tunnel is not lined for 38 percent of its length. It was drilled, with a diameter of 13.5 feet, through solid granite. The rest of the tunnel is ten feet in diameter and lined with concrete. Shaped like a horseshoe, the tunnel is designed for a flow capacity of 470 million gallons per day.

O'Shaughnessy considered all private contracting bids for the Mountain Tunnel to be "extravagantly high" and rejected them. The excruciatingly difficult work was assigned to Hetch Hetchy's City forces, taking the best of men, and putting the engineer's skills to an acid test.

The excavation work was conducted from twelve working faces. The headings from each face had to match up, horizontally and vertically, when crews working toward each other "holed through." Of the working faces, four were portals, four were from adits (passageways leading to the tunnel) and four from the bottom of the two shafts — Second Garrote Shaft, 786 feet deep, and Big Creek Shaft, 646 feet.

The tunnel was completed in 1925, at a cost of $25 million. Most of Mountain Tunnel is an average of 1,000 feet below the surface. Where it crosses the gorge of the South Fork of the Tuolumne, it was interrupted by a 9.5 feet diameter pipe, 225.5 feet long. In the mid-1960's the pipe was replaced by a U-shaped tunnel under the stream bed.

PRIEST RESERVOIR AND POWER TUNNEL

The west end of Mountain Tunnel comes out some 19 miles east of Early Intake. The Hetch Hetchy water is discharged into Priest Reservoir, a regulating reservoir for forebay capacity and flexible operation of Moccasin powerhouse. Near the top of Priest Hill, a reservoir was formed by blocking Rattlesnake Creek, a tributary of Moccasin Creek, with a hydraulic and earth fill dam having a concrete core. The dam is 148 feet high, 1,600 feet long and 660 feet thick at the base. It was built by Hetch Hetchy forces at a cost of $1 million. A concrete lined spillway protects against overtopping and a tunnel serves as an additional outlet to drain the reservoir.

Priest Reservoir receives the full force of the Hetch Hetchy flow from Mountain Tunnel. A concrete gate tower controls and regulates water release through the power tunnel to the brow of the hill above Moccasin. A 160 foot high surge shaft is near the downstream end of the tunnel. The power tunnel is 5,370 feet long, horseshoe shaped, concrete lined, narrowing from 19 feet to 13 feet in width, and has a capacity of 800 million gallons per day. Its cost was $1.3 million. The power tunnel connects with three penstocks, 5,349 feet long, which direct the water into the Moccasin powerhouse 1,316 feet below. The penstocks were originally built for $2.5 million.

"High line" cableway, capable of supporting a 5 ton load.

MOCCASIN POWERHOUSE AND DAM

The old powerhouse is 225 feet long, 98 feet wide and 67 feet high. A steel frame building with reinforced concrete walls, its massive foundations rest on bedrock. The powerhouse and its machinery cost $2.4 million. During its 44 years of active service, four generators, rated at 20 kW each, produced $115 million worth of electrical power.

The powerhouse was designed in California Mission style with a tile roof and arched arcades. Located on the bank of Moccasin Creek, near the junction of State Highways 49 and 120 — the Mother Lode Stage Coach and the Big Oak Flat roads — at the foot of the infamous Priest Grade leading to Stanislaus National Forest and Yosemite National Park.

An arduous passage from the earliest days, the old Priest Grade climbs 1,575 feet in two miles. The new road, State Highway 120 — across Grizzly Gulch from the original — makes the same climb in eight miles. The name came from the Priest Station Hotel at the top of the grade. The hotel was operated by Mrs. William Priest until 1905.

Only the shell of the old powerhouse building now remains, but around the site are the homes, offices and shops of Hetch Hetchy's Operations Division — headquarters for construction and maintenance on the entire dam, power and aqueduct system.

New Moccasin powerhouse started service in 1969, rated at 90 kW. Of the outdoor type, the installation has two generators, each rated at 45 kW capacity. It is adjacent to the old powerhouse site, using the same penstocks. This Moccasin powerhouse was built for $8.3 million, significantly more than its predecessor. The new powerhouse is much more sophisticated, however, requiring less manpower for operation and maintenance, and earning $250,000 more annually than the old plant did.

The Moccasin afterbay re-regulating reservoir was

created by an earth fill dam 50 feet high and 855 feet long. Later, another concrete dam, 321 feet long, was built upstream of the afterbay. This was to keep potentially contaminated water out of the afterbay. Moccasin Creek flood waters are filled with debris and extremely muddy. They are excluded from the clean supply which flows out of the powerhouse and into the Foothill Tunnel. Moccasin Creek waters are diverted through a 2,900 foot long bypass tunnel on the floor of the afterbay and discharged below Moccasin Dam, where they continue downstream along the original creek bed. Drinking water for San Francisco, however, enters the Foothill Tunnel upstream of Moccasin Dam at the afterbay gate tower. Should the need arise, drinking water can be diverted at the powerhouse tailrace directly into the Foothill Tunnel aqueduct, bypassing the afterbay reservoir.

This Moccasin Reservoir system of dams and diversions was completed in 1936 at a cost of $900.000.

FOOTHILL TUNNEL AND DON PEDRO

From Moccasin, San Francisco's drinking water continues westward in a now entirely enclosed conduit of tunnels and pipes, discharging into the San Francisco Water Department distribution system at Alameda East Portal. The first leg of this journey is the 15.8 mile Foothill Tunnel through the Sierra Nevada western foothills. At Oakdale Portal, south of Knight's Ferry, connection is made with the San Joaquin Valley pipelines.

Tunnel construction started in 1926. Construction headquarters had been moved from Groveland to Hetch Hetchy Junction in November 1925. After the opening of Pedro Adit, the tunnel was soon being drilled and blasted from ten separate construction faces — four from two shafts at Hetch Hetchy Junction and Rock River, four from Pedro and Brown adits, and two from the tunnel portals.

The Foothill Tunnel line crosses the Tuolumne River canyon at Red Mountain Bar, some five miles west of Moccasin. The river crossing was made with an inverted siphon — 770 feet of 9.5 feet diameter steel pipe in a trench blasted from bedrock and embedded in concrete 18 inches to two feet thick. The pipe interior is coated with 1.5 inches of cement mortar.

The Red Mountain Bar siphon was not initially required, but the canyon would soon be flooded to a depth of 80 feet by the Don Pedro reservoir. The Don Pedro Dam was being constructed at the same time as O'Shaughnessy Dam by Turlock and Modesto Irrigation Districts.

During the three years of work on the Foothill Tunnel, a narrow gauge railway was laid from the east bank of the Tuolumne to the Brown Adit, 1.5 miles away, and into the tunnel itself. A siding was built on the west side of the river, alongside the Hetch Hetchy Railroad main line. The river was crossed by a half-mile long, Lidgerwood

Courtesy of S F Public Library

Louis F. Byington

type, steel cable "high line." The cableway could carry a five-ton load of supplies and men from the main line siding, across the river canyon, to the narrow gauge line in two minutes. At the time, the cableway set a world record in span length for a hoisting and conveying cable line.

Work on Foothill Tunnel was started from six work camps by Hetch Hetchy City forces. Installing all "appurtenances," (a favorite word with engineers) such as water systems, power and telephone lines, roads, camps and other construction facilities, City gangs also drive some 1,000 feet of tunnel in the work face headings to expose the geology to private contractors for later bid.

Three of the work camps were subsequently turned over to contractors who bid successfully on the project. As a result of the later bid policy, the City was assured of reasonable bids. Not only did a spirit of competition grow between the City's work forces and those of contractors working on adjacent sections, but direct comparisons of costs for similar work became possible.

Completely outworking the private contractors, Hetch Hetchy's City forces set a new record for one month's tunneling excavation in March 1926 — 781 feet at Hetch Hetchy Junction east heading. Six months later City forces broke their own record at the same work face — 803 feet in September — setting a new national record for this type work.

Foothill Tunnel was completed in 1929, at a total cost of $8 million. Chief O'Shaughnessy later reported that tunneling costs for City work came to $35.53 per foot — contractor cost was $40.49. City costs for placing concrete lining came to $36.11 per foot, while the contractors cost $47.38.

SAN JOAQUIN PIPELINES

From Foothill Tunnel, Hetch Hetchy waters are shunted, under pressure, 47.5 miles across California's San Joaquin Valley through three pipelines, placed eight to nine feet underground for most of their length. Entering the pipelines at Oakdale Portal, where valves control flow in all three lines, the water is discharged into the Coast Range Tunnel at Tesla Portal, seven miles south of Tracy. The Aqueduct right-of-way is 100 feet wide and provides space for four parallel pipelines, along with Hetch Hetchy's power transmission lines overhead. Dropping below sea level, the pipelines pass 15 feet under the deep water navigable San Joaquin River and nearby Elliott Cut, where they are supported by timber piles and encased in reinforced concrete jackets.

Construction of Pipeline #1 started in 1931 and was completed the next year. Having a diameter varying from 56 to 72 inches, the pipe is welded and riveted. At construction, each section was asphalt coated and wrapped with asphaltic felt. When pipeline #2 came on line, the interior asphalt lining was removed and replaced with

cement mortar. With a construction cost of $5 million, the capacity of Pipeline #1 is 60 million gallons per day.

Pipeline #2 entered service in 1953. With an inside diameter of 61 inches throughout its length, the line includes 28.5 miles of welded steel pipe, coated and lined with cement mortar, and 18.5 miles of reinforced concrete pipe. The line cost $12.3 million and increased the aqueduct capacity by 80 million gallons to 140 million gallons per day.

Pipeline #3 is the largest of the three — east of the San Joaquin River it is 78 inches in diameter, lined with cement mortar, and west of the river 79.5 inches, lined with coal tar enamel. Completed in 1968 at a cost of $19.5 million, it increased the aqueduct capacity by 160 million gallons per day, or a total capacity for all three pipelines of 300 million gallons per day.

Pipeline #4 is currently only "on paper." When the Water Department service area demand so requires, construction of this pipeline would bring the aqueduct capacity to at least 400 million gallons per day.

At the San Joaquin River crossing, automatic pressure relief valves on all three lines discharge into the river in case of excess pressure, or should a break occur in the line.

Laying 42" Submarine Pipeline across Newark Slough February, 1925.

COAST RANGE TUNNEL

One of the largest and most dramatic of the Hetch Hetchy undertakings, Coast Range Tunnel is the final leg of the journey for Sierra Nevada waters before reaching the San Francisco Bay Area Region. This 28.5-mile long tunnel through the Coast Range Mountains is in two sections — a 25-mile long continuous tunnel from Tesla Portal to Alameda Creek, which was the longest in the world upon completion, and a 3.5-mile segment from Alameda Creek to Irvington Portal near Mission San Jose. At Alameda Creek the two tunnel segments are connected by a multiple-pipe, inverted siphon, one-half mile long across the creek and Sunol Valley. At the siphon, connections have been made to transport water from former Spring Valley sources of the San Francisco Water Department through the Hetch Hetchy Aqueduct Bay Division.

Hetch Hetchy's master plan scheduled construction to start in the winter of 1925, but the work had to await approval of the budget by the Board of Supervisors. When the budget was finally adopted in 1927, tunnel drilling started without delay.

Part of the two-year delay was caused by an increasing number of critics who viewed with alarm the hazardous working conditions, possible gases, ground water, quicksand and swelling ground. Some engineers and political groups wanted the Hetch Hetchy water pumped over the Coast Range to save time and the expense of tunneling. O'Shaughnessy proved that a pipeline for 60 million gallons per day, plus the pumping costs, would cost almost as much as a 200 million gallon per day gravity flow tunnel. Also, the pipeline would require a supplementary line in 12 years, while the pumping costs would go on forever!

Possible earthquakes were also forecast by tunnel critics. This threat was well known to the engineers; fracture areas of two earthquake fault lines were identified. The tunnel was designed to withstand earth tremors — some sections of the concrete lined tunnel were even given flexible joints.

Swelling ground was also a problem. Under Crane Ridge, at a depth of 2,500 feet, the 18 foot diameter tunnel bore, supported and braced by timbers 18 inches square, was squeezed by ground swelling. In 24 hours the tunnel bore was reduced to three feet all around, turning the heavy timbers to kindling. In a few days the tunnel became so narrow that workers crawled through with difficulty.

In solving this problem, Hetch Hetchy engineers excavated the tunnel bore to an oversize diameter and set ringlike bands of gunite, 2 1/2 to 3 feet thick, mixed with a very high cement content, within the tunnel, leaving a one-foot gap for the swelling ground. The ground supporting gunite lining "took its set" and developed sufficient strength to hold before the swelling ground filled the gap.

The problems have not recurred after a half century of constant use. Regular inspections confirm the tunnel to

Modesto Irrigation District and Turlock Irrigation — Elmer G. Robinson, S.F. Mayor with officials at dedication at Cherry Valley Dam.

be virtually as sound as the first day water passed through it.

Lined entirely with concrete, three feet thick in some places, the 10.5 foot diameter tunnel follows the general line recommended in the 1912 Freeman Plan. O'Shaughnessy's engineers moved the final specific route a little to the south to avoid, as much as possible, areas to the north suspected of producing noxious and inflammable gases, especially hydrogen sulphide and methane, which were anticipated in the marshier areas.

With the start of construction, the 25-mile long tunnel was divided into six work sections or headings by the two portals at Tesla and Alameda East, and five shafts: Thomas, Mitchell, Mocho, Valle and Indian Creek. Methane gas was first detected in Mocho Shaft and more stringent precautionary safety measures imposed.

Despite the precautions and stringent safety measures, the gang working the east tunnel of Mitchell Shaft encountered methane gas on July 17, 1931. In the resultant explosion twelve lives were lost. Several investigations following the tragedy concluded that Hetch Hetchy had conducted tunneling operations under the most strict safety methods used in California and the nation. The Alameda County Coroner's Jury found San Francisco and its agent Hetch Hetchy blameless. Although impossible to isolate the cause conclusively, the investigations established that neither electric wires nor locomotives had ignited the gas. Both Wolf Safety Lamps for the detection of inflammable gases were broken. In violation of safety rules, matches and smoking materials were found in two of the victims pockets.

These and other delays beset construction progress. The first of the "money" delays was a two-year wait for funds to start the work, which set the entire work schedule back. There were also delays "to conserve funds." At times, during the depression years, investment money was in short supply and several work headings were shut down for various periods "pending the sale of bonds to finance the work."

By 1932, O'Shaughnessy had been City Engineer and Chief of the Hetch Hetchy Project for two decades. Delivery of Sierra Nevada water to San Francisco was still two years away from realization. O'Shaughnessy's fiery and abrasive temperament over the years was starting to bear bitter fruit.

Critics and second-guessers caused a two-year delay in the initial funding for the Coast Range Tunnel, setting the construction schedule back accordingly. The onus for that delay was placed on Chief O'Shaughnessy. The project had cost the lives of twelve men. Engineering problems which had been solved handily, episodes of ground swelling and quicksand, were seized upon for additional criticism. O'Shaughnessy refused to find jobs for friends of important people, publically challenged some members of the Board of Supervisors, and testily showed some carping newsmen out the door of his office. Mayor Rolph was in Sacramento, having been elected Governor of California in 1931, and was no longer immediately available to the irascible Chief.

The new City Charter of 1932 went into effect, forming the Public Utilities Commission controlling Hetch Hetchy, Municipal Railway, Water Department and Airport. Edward G. Cahill was appointed first General Manager of Utilities and Lloyd T. McAfee, an assistant chief engineer under O'Shaughnessy, was appointed Manager and Chief Engineer of Hetch Hetchy. O'Shaughnessy was no longer City Engineer — the former Chief was given an office in the Water Department and the title "consulting engineer." According to recollection, however, he was given no work and consulting with him was discouraged.

The new Charter required public bidding to complete the Coast Range Tunnel project. Hetch Hetchy also had

Public Utilities Commission (1932) – Front Row, left to right: Fred Boeken, John J. Sharon, L.T. McAffee, Nelson A. Eckart, Paul J. Ost, B.M. Doolin, Jackson T. Carle. Second Row: Comissioners Daniel C. Murphy, John H. McCallum, President Lewis F. Byington, Commissioners George Filmer, Edwin M. Eddy. Standing: A.F. Freitas, Edward G. Cahill, M.M. O'Shaughnessy, F.B. Gibbon.

Mocho Shaft "Tunnel Crew."

the right to bid and came in at $5,257,665, over half a million dollars less than the next lowest bid. When City Forces finished the project they still had some $1.5 million left over.

The final "holing through" of the Coast Range Tunnel came on January 5, 1934, between the Mitchell and Mocho access shafts, in the presence of, among others, Mayor Angelo Rossi, PUC members Lewis Byington and Erwin Eddy, and Utilities General Manager Edward Cahill. The ceremony of drilling the last 12 inches was delayed for the arrival of the 70-year-old O'Shaughnessy, who took the first handshake through the "holed" tunnel from Tunnel Foreman Pete Peterson.

In addition to the twelve men, the tunnel cost was $28 million.

BAY DIVISION PIPELINES, PULGAS AND CRYSTAL SPRINGS BYPASS TUNNELS

From Irvington Portal, which is within the San Francisco Water Department catchment and distribution area in Alameda County, the Hetch Hetchy waters had only to travel another 25 miles across the Bay to Pulgas Tunnel in San Mateo County.

Four Bay Division pipelines and their appurtenances — that engineer word again — were constructed by Hetch Hetchy and the San Francisco Water Department over a half century period. They now deliver their Hetch Hetchy and East Bay waters by gravity flow to Pulgas Portal in San Mateo County.

Construction on the 1.7-mile long Pulgas Tunnel started June 23, 1922. By 1924 it carried Spring Valley water under a lease agreement six years before the City was to purchase the private water system in 1930.

By the end of 1924 it appeared that all of the $45 million originally authorized in 1910 had been expended. In October, San Francisco voters approved an additional $10 million to complete the job, but this new money was not to be available until after January 1, 1925.

An ultimate alternative seemed to be a special election for a $1 million bond issue. But this would cost at least $35,000, delay the work six months or more, and lay-off some 500 trained men for that period with no guarantee of getting them back afterward.

The August 12, 1912 order of the State Railroad Commission, the water arbiter at the time, and the April 17, 1922 agreement between Spring Valley and San Francisco, presumed developing the Spring Valley water system until the City bought out the company and integrated its facilities with Hetch Hetchy to form the ultimate

Harry Lloyd at Lake Lloyd.

municipal water supply. Rather than go for the $1 million bond issue and the losses to be incurred, Hetch Hetchy approached the Spring Valley Company who agreed that "all cooperation necessary should be lent to the City to solve this financial problem."

Spring Valley Water Company advanced four annual payments of $250,000 each, as pre-paid rent for using Hetch Hetchy's Bay Division of the aqueduct. The private company did not make any money on this deal. It used its own good credit to borrow the money at the lowest available rates. San Francisco compensated Spring Valley for the interest costs so that the water company neither made nor lost money in the transaction. But, at the same time, Spring Valley was required to borrow money to finance its own construction works.

Under these difficult circumstances, Spring Valley advanced $1 million to the City so that Hetch Hetchy work could be continued without losing the trained work force and other losses which would have occurred had the Hetch Hetchy project been shut down.

Regarding this transaction, the *Oakland Tribune* editorialized on December 19, 1924, referring to "controversies which have hindered and threatened to halt the work . . ." The Tribune opined, "In the light of history, it seems a little incongruous that at the most critical period in the Hetch Hetchy work, and when the money was not available, the much-maligned Spring Valley Water Company came to the front to furnish the funds to complete the job. Volumes might be written on the subject, but suffice to say the company is to be commended . . . regardless of the fact that those who berated it and made it a target are some of those who are most prominent in Hetch Hetchy circles . . ."

Pipeline #1 was constructed 60 inches in diameter except for half a mile of 42-inch flexible-joint, cast iron pipe in a trench 25 feet deep in the mud and 75 feet below the water surface at Newark Slough and Dumbarton Strait. Completed in 1925 at a total cost of $6 million, the 21-mile long line was put to use immediately per the agreement with Spring Valley Water Company to augment their own small line carrying Alameda waters to the peninsula. When pipeline #1 entered service, Spring Valley's peninsula storage contained only 70 days water supply for the City.

Pipeline #2 is the same length and uses the same right-of-way as Pipeline #1, but has 62- and 66-inch diameters. Completed in 1936, the cost was $4 million.

Pipelines #3 and #4 are each 34 miles long and they follow a right-of-way around the south end of San Francisco Bay. Separating the four pipelines into two pairs created service advantages and provides insurance against water loss from earthquake or other causes. These lines are of riveted steel, welded steel, reinforced steel cylinder and pre-stressed concrete. Completed in 1956, #3 is 72 to 78 inches in diameter and cost $10 million. Pipeline #4 is the largest, with a diameter ranging 84 to 96 inches. Its final eight-mile link was completed June 14, 1973 at a cost of $5.6 million, bringing total transbay transmission capacity to 307 million gallons per day.

Crystal Springs Bypass Tunnel was the realization of a Water Department plan to bring water from Hetch Hetchy and the Sunol Filtration Plant into San Francisco and northern San Mateo County without entering Crystal Springs Lake. Work on the 3.25-mile long, 9 feet in diameter, concrete lined tunnel, along with the 4,480-foot long, 7 1/2 foot diameter connector to existing Crystal Springs pipelines, was completed in 1968 at a cost of $8.6 million. In 1975, a 60 million gallon capacity, covered balancing reservoir with attendant pumping station, was built at a cost of $4.6 million.

By October 1934, San Francisco voters had authorized seven bond issues to finance the Hetch Hetchy work; $600,000 in 1910, $45 million in 1910, $10 million in 1924, $24 million in 1928, $6.5 million in 1932, $3.5 million and $12.095 million in 1933, for a total of $101.695 million.

Including the 12 lost in the Coast Range Tunnel disaster, getting Sierra Nevada water to San Francisco had cost the lives of 89 men. The first flow of mountain water into the San Francisco distribution system was an historical event to be properly observed on October 24, 1934, the day it happened.

Accompanied by the Municipal Band, Public Utilities President Lewis Byington introduced the builders of Hetch Hetchy. Interior Secretary Harold Ickes, Mayor Angelo Rossi and Supervisor Jesse Colemen addressed the assemblage and the nation over the Columbia Broadcasting System coast-to-coast radio network paying tribute to Chief O'Shaughnessy, but he was not there to hear it.

Just 16 days before, in the early morning hours of Friday, October 12, the 72-year-old O'Shaughnessy, complaining of a pain over his heart, passed away at his home.

CHERRY VALLEY DAM AND LAKE LLOYD

When the mountain water reached San Francisco in 1934, the City's engineers headed back to the Sierra to increase the height of O'Shaughnessy Dam and add to the capacity of Hetch Hetchy Reservoir. San Francisco had approved a $3.5 million bond issue for this project in November 1933. Transbay Construction Company made the low bid of $3,219,965 and construction started in January 1935.

By the time this project was finished, the economy of Tuolumne County had been given a timely boost. This was when the nation was making its way out of the great depression. San Francisco was offered a 30 percent grant from the National Relief Administration, provided all available unemployed Tuolumne workers were put on the job.

The State Emergency Relief Act provided some 600 maintenance workers to help rebuild the Hetch Hetchy Railroad bed and tracks. But this time Hetch Hetchy did not run the railroad. Sierra Railway came in with the low bid and railroad operations started again on May 13, 1935.

Completing the raising of O'Shaughnessy Dam in 1938, Hetch Hetchy engineers moved on to Cherry Creek Canyon, about 17 miles northwest. The Raker Act had authorized a third impounding reservoir in this valley. Additional storage had been planned to service expanding water supply needs and to develop additional electric power resources as early as 1939. Mutual interest in these two concepts developed between San Francisco and the Modesto and Turlock Irrigation Districts resulting from extensive studies on Tuolumne waters conservation and development. San Francisco required additional mountain water storage to assure its supply, while the Irrigation Districts wanted additional storage for increasing irrigation and to minimize water shortages in dry years. Then the Army Corps of Engineers showed interest in protecting the lower Tuolumne and San Joaquin Rivers from flood damage.

Starting exploratory work in the Cherry Valley in 1941, San Francisco spent $200,000 over the next eight years to protect its rights and program the way until the four interested agencies entered into a cooperative agreement in 1949. The agreement provides and requires:

> San Francisco and the Irrigation Districts to modify their existing facilities, construct new facilities, and operate both to reserve reservoir space for protection against Tuolumne River floods, in accordance with Corps of Engineers established regulations.
>
> San Francisco to construct a reservoir in Cherry Valley immediately.
>
> The Irrigation Districts, at a later date, to develop a new, larger reservoir on the lower Tuolumne, below the old Don Pedro Dam, which would then lie 200 feet under the maximum water level.
>
> That upon completion of this larger reservoir, all flood control operations on the Tuolumne would be transferred to it.
>
> For flood control benefits, the Federal Government to pay $9 million toward construction of the $13 million Cherry Valley Reservoir and to pay a subsequent amount (about $5.4 million) toward building the New Don Pedro Reservoir.
>
> For the right to use a stipulated amount of storage space in New Don Pedro, San Francisco to pay $45 million toward its construction.

The Cherry Valley project started in 1950. Heavy equipment had to be carried to the work site, so 26 miles of roads were built through rugged canyons and over mountain ridges. Power was supplied by a 10-mile long, wood pole line from the venerable Early Intake Powerhouse. A diversion tunnel, 17 feet in diameter and a quarter-mile long, was drifted around the damsite.

Five years later, in 1956, the huge Cherry Dam was complete — 330 feet high above bedrock, 2,600 feet long, and 1,320 feet thick at the base. A composite earth and rock embankment dam, the central impervious core is of compacted decomposed granite. The diversion tunnel was made a permanent outlet and a six mile long horseshoe shaped pressure tunnel, 12 feet wide and 12.5 feet high, was bored through granite to Dion R. Holm Powerhouse. The tunnel has a 400 foot tall surge shaft and a rock trap near the downstream portal.

The reservoir formed by Cherry Dam was named Lake Lloyd in honor of Harry E. Lloyd, who was General Manager and Chief Engineer for Hetch Hetchy, 1952-1961.

Lake Lloyd water storage is for several purposes — conservation, flood control and power generation — but not for direct contribution to San Francisco's domestic water supply! Water releases are for power generation at Holm Powerhouse and to meet downstream irrigation priorities under the Raker Act. Water credits so earned

reserve Hetch Hetchy water for the City's domestic water supply. The Lake Eleanor watershed supplements storage in the Cherry system by a mile-long tunnel drifted through the ridge between the two lakes which drains Eleanor water into Lake Lloyd.

DION R. HOLM AND ROBERT C. KIRKWOOD POWERPLANTS

Developing Dion R. Holm Powerhouse on the Cherry, six miles downstream from the Cherry Valley Dam, and its neighbor, Robert C. Kirkwood Powerhouse, on the Tuolumne just upstream from Early Intake, was delayed until the 1960's. Before they could be built, a plan, acceptable under the Raker Act provisions, had to be worked out to dispose of the electrical energy to be created. Since San Francisco does not own its municipal electric distribution system, Hetch Hetchy energy is delivered at bulk transmission voltages to other agencies for resale, or for wheeling transport to the City's municipal loads and customers under contractual agreements.

Holm Powerhouse came on line in 1960, and is the largest of the three Hetch Hetchy powerhouses. Each of its two vertical-shaft, turbine-driven generators is rated at 67,500 kW. Voltage is stepped up to 230 kV to transmit the power 1.5 miles to Early Intake Switchyard.

Water for the powerhouse comes from the Cherry Power Tunnel and enters a 6,700 foot long steel, single pipe penstock. Tapering from 7.5 feet in diameter at the top to 5 feet at the powerhouse, the penstock drops the water 2,100 vertical feet. To withstand the high pressure, the penstock pipe is made from steel plate increasing in thickness from 3/4 inch at the top to 2.5 inches at the bottom.

Plant, tunnel, penstock and all equipment except transmission lines represent a San Francisco investment of $25 million.

The Dion R. Holm Powerhouse was named on August 25, 1967 to memorialize the former City Attorney who served as Hetch Hetchy counsel during the early operating years and who was a devoted advocate of the water and power system.

The 11-mile long Canyon Power Tunnel takes Hetch Hetchy water from the base of O'Shaughnessy Dam through a steel pipe, nine feet in diameter, encased in concrete. Mostly unlined, it is horseshoe shaped, 14 feet wide and 14.5 feet high. Sloping 10.5 to the mile, the pressure tunnel can carry 550 million gallons per day. It was completed in 1965 at a cost of $11 million.

The Kirkwood Powerhouse takes Canyon Tunnel waters at the head of a 1,600 foot long penstock for a vertical drop of 1,100 feet. Two vertical shaft turbines each drive a water cooled generator rated at 33.75 kW at 13.9 kV. Transformers step up the power to 230 kV for transmission to Early Intake Switchyard, where it joins power from Holm powerhouse for transmission to Moccasin and through the system.

Kirkwood Powerhouse came on line in 1967, and it was dedicated on August 25 to the memory of the General Manager of Public Utilities, 1959 — 1964, who passed away while in office. Cost of the penstock was $2.3 million — for the powerhouse it was $5.6 million.

These two powerhouses are normally operated by remote control from Moccasin Powerhouse, some 20 miles to the west. Push button operations start and stop generating units, adjust generator speed and voltage, take readings and perform switching. The Moccasin control room not only operates the three power plants, it also monitors their output into the 115 kV and 230 kV power transmission systems.

Hetch Hetchy's three power plants generate over two billion kWh of electricity a year. A quarter of that goes to satisfy San Francisco's municipal needs, including the Municipal Railway and street lighting. The balance is sold to central California irrigation districts and industrial customers. In 1984, these sales produced over $70 million in gross revenues and $42 million for the General Fund and San Francisco taxpayer relief.

POWER TRANSMISSION LINES

Two high voltage systems, normally independently operated, deliver Hetch Hetchy power to the Turlock and Modesto Irrigation Districts, and to the Pacific Gas and Electric Company. Each delivery system includes its own line, switchyards, substations, circuit breakers, transformers and automatic protective equipment.

The Moccasin-Newark line operates at 115 kV for its 98.5-mile length. The three phase (six wires) circuits are carried by 506 steel towers, each 97 feet tall, except at the San Joaquin River crossing where they are 208 feet tall. Following the Aqueduct right-of-way as far as Tesla Portal, the line was built during 1923 and 1924, terminating at the PG&E Newark substation.

Power generated by Holm and Kirkwood Powerhouses starts from Early Intake Switchyard on a separate steel tower transmission line operating at 230 kV, double circuit. Via Moccasin, the line carries the power 48 miles to Warnerville substation, near Oakdale, where the voltage is reduced to 115 kV for delivery to Turlock's Oakdale substation and Modesto's Station J, 12.5 miles further down the line.

The circuits of the two lines are interconnected to the extent that the Moccasin-Newark line is tapped by irrigation district substations, while Warnerville is also a connection point with the PG&E 230 kV system.

NEW DON PEDRO

As specified in the 1949 cooperative agreements with San Francisco and the Corps of Engineers, Modesto and Turlock Irrigation Districts proceeded with their construction of a massive new dam, about 1.5 downstream from the Don Pedro Dam they had built on the Tuolumne in 1923. On its completion, the old Don Pedro Dam had been the highest dam in the world. Now, less than half a century later, it was to lie 200 feet beneath the surface of a tremendously expanded reservoir, with a 165-mile long shoreline, extending 24 miles into Moccasin Creek to the doorstep of Moccasin Powerhouse.

The San Francisco Public Utilities Commission invested $45 million of the 1961 voter approved $115 million water system bond issue in the project, in return for a Hetch Hetchy credit of 740,000 acre feet of exchange water storage space in the new reservoir. This increased San Francisco's high mountain storage capability to 1.4 million acre feet — enough to increase daily water diversions by 190 million gallons, or a total daily delivery capacity of 400 million gallons.

Along with San Francisco's investment, the Army Corps of Engineers contributed $5.4 million for flood control and dam construction started in 1967.

A massive rockfill dam rising 580 feet, it creates the reservoir, Lake Don Pedro, inundating the old dam upstream, and storing some two million acre feet of water. Total cost of the project was $100 million.

On May 22, 1971, some 3,000 persons gathered for the dedication ceremonies and an address by San Francisco Mayor Joseph L. Alioto, followed by a beef barbecue hosted by the Turlock Irrigation District.

Conservation, Preservation and Recreation

California and other west coast areas experienced a record drought during 1976 and 1977 — the result of back-to-back years of less than average rainfall. The impact of these two years was severe and the scars are still evident. When the drought broke, Water Department and Hetch Hetchy supply was just over 400,000 acre feet — less than half the available storage capacity. Having so much water still on hand after two years of service to 1.8 million users is a testimonial to the planners and builders of Hetch Hetchy and the persevering San Franciscans who succeeded in obtaining ownership of their municipal water supply system.

A water rationing program was adopted by the Public Utilities Commission on March 22, 1977. Becoming the pattern for other California cities, the program had a goal of reducing water consumption by 25 percent. By the time the program ended on January 24, 1978, water consumption levels were averaging 35 percent below the levels of 1976, the last previous normal year.

The drought and rationing produced a public water conservation awareness or ethic that the Public Utilities Commission was quick to apply to a permanent, voluntary reduction in water consumption. The permanent program called for a 15 percent reduction in water use. Results exceeded expectations when consumption settled at a 20 percent reduction following the end of rationing. For fiscal year 1983/84, San Francisco water consumption remains at the same level. System wide, water consumption is just over 90 percent of predrought use.

The Water Department conservation program pointed out how users could reach conservation goals merely by not wasting water while satisfying their reasonable water needs. Another dividend gained was postponing the requirement for costly capital improvements to increase water delivery capabilities.

Preservation is a way of life with the water industry. A ruined environment will not produce potable water. When it comes to maintaining the integrity of the watersheds in the Sierra Nevada or in the San Francisco Bay Area, nothing can impede Hetch Hetchy or the Water Department.

With justifiable pride, land erosion control and reforestation projects are pointed out. Having preservation as part of their character, City employees assigned to the water supply system have always improved the areas of their water works.

Die-hards who would still continue the Sierra dispute are reminded that there were other uses in mind for the Hetch Hetchy Valley at the turn of the century. In 1903-1904 a proposal to make the valley a summer resort rivaling Yosemite actually got underway, but it failed in less than a year.

This failure was fortunate, because in the words of Congressman Francis Burton Harrison, protesting the San Francisco Hetch Hetchy Plan on December 12, 1913, "The Hetch Hetchy Valley is the only large level place in the northwest portion of the park where hotels and permanent camps can be located."

Thousands of back packers and trail hikers now prefer Hetch Hetchy's scenic Grand Canyon of the Tuolumne to the overdeveloped, smog filled, littered, automobile and people clogged Yosemite Valley.

Back on the San Francisco Peninsula in 1967, the Public Utilities Commission invoked a new Federal law to win an acceptable route for the Junipero Sierra Freeway (I-280), then under construction, and to preserve the San Mateo County watershed inviolate. The State had planned to lay a 4.2 mile section of the freeway along the shore of Crystal Springs Lake in the southern portion of the watershed. The U.S. Department of Interior, having a voice in the use of federal highway funds, rejected the State's plan and forced relocation of the route to the crest of Pulgas Ridge.

In 1969, easement agreements were made between the federal and state governments, and with San Francisco and San Mateo County, to keep the watersheds unchanged. The agreements set aside 19,000 acres, including Crystal Springs lakes, San Andreas lake and watershed lands east of Montara Mountain, as a wilderness area to be held as an ecological preserve in perpetuity. The area is dedicated only to water supply and entry is controlled by the Water Department. A scenic and recreation easement covers the 4,000 acres in the southeast section between the lakes and Pulgas Ridge. The Golden Gate National Recreation Area administers these easements for the federal government.

As the Water Department properties in San Mateo County became an island of unspoiled wilderness in the midst of a rapidly developing urban area, so do the water producing properties in Alameda and Santa Clara Counties play a major role in retaining natural beauty in the area.

The lovely Sunol Valley owes much of its charm to the 24,267 acres devoted to the Water Department's production system. Alameda County planners have joined with the zealous protectors of this refuge for lovers of open space.

Within the highly urbanized complex of the City and County of San Francisco, Water Department properties serve double duty to enhance recreational opportunities for City dwellers. Covered reservoirs and other properties provide public recreation facilities, operated by the Recreation and Park Commission, including tennis courts, parks, playgrounds, golf courses, and neighborhood green space.

EPILOGUE

The Public Utilities Commission Annual Report for fiscal year 1983/84 lists San Francisco's net capital investment in the water and power system as of June 30, 1984, to be over $578 million, with $39.5 million in current long term bonds outstanding.

The book value, before depreciation, of property, plant and equipment acquired and developed by the City is over $653 million, with over $8 million worth of construction currently in progress.

During the year ending June 30, 1984, operating revenues from water and power sales exceeded $124.5 million, or a 21.5 percent annual return on the City's net capital investment.

The revenues covered all costs of operating, maintaining and developing the Water Department and Hetch Hetchy. They serviced interest and principal payments on all outstanding water and power bonds, absorbed the power costs for San Francisco's municipal buildings, street lights and the Municipal Railway, and still transferred $25 million to the General Fund as relief for local property tax payers.

FUTURE OUTLOOK

Spring Valley Water Works installations are up to 120 years old. Asphalt treated, riveted iron pipes up to 72'' in diameter are under constant pressure. There is an ongoing need, not only for maintenance, but also for replacement of the older sections of the system, and, to prevent future water shortages, construction of additional capability to transport Hetch Hetchy water at the 400 MGD rate for which the system was designed.

Water treatment plants are designed with a useful life of 20 to 30 years. Sunol started operations 22 years ago. In November, 1984 San Francisco voters approved, 179,087 to 55,651, Proposition B, a $104 million water service revenue bond issue. These funds are being used to rehabilitate and increase the production capacity of the 12-year-old San Andreas Filter Plant by 40 MGD to meet Peninsula water requirements through the year 2030. Because Crystal Springs waters currently seldom meet turbidity standards of the California Department of Public Health Services, the Water Department avoids routine use of these waters. Outages at other facilities have required using Crystal Springs waters and future outages can be expected to require using the currently substandard water. This problem is being solved by building a new 40 MGD Crystal Springs Water Treatment Plant and a new 30 MG balancing reservoir to equalize stress for Bay Division service requirements. The new facilities will permit using water from Crystal Springs Reservoir without first channeling it through the San Andreas Reservoir and Treatment Plant as is presently required.

Of the 400 MGD now being taken at O'Shaughnessy Dam, only 300 MGD can be accepted at Oakdale East Portal because of the limited capacity of San Joaquin pipelines 1, 2 and 3. These 100 MGD represent 25% of San Francisco's entitlement under the Raker Act and the agreement with Turlock — Modesto Irrigation Districts in return for San Francisco's $45 million contribution toward the construction of New Don Pedro. The 100 MGD that the pipelines cannot currently accommodate is being discharged into Don Pedro and builds up San Francisco's water bank entitlements with Turlock-Modesto.

At a budget cost of $27.5 million, a third generator is being installed at Kirkwood Powerhouse with the production capacity of 36,500 kW. This unit will permit the powerhouse to use the full capacity of Canyon Power Tunnel during spill periods and will provide sufficient power generation capability during maintenance periods.

Water, presently being spilled and wasted at O'Shaughnessy Dam, Moccasin, Early Intake and Calaveras Dam, can be harnessed to produce power by so-called low head generating plants. Such a plant is now under construction at Moccasin. A new, $5 million, powerplant, rated at 1.5 MW, is being designed for O'Shaughnessy Dam. These low head generating plants will provide additional peak production for government and industrial electrical loads.

The results of these past seven decades of San Francisco's program of municipal ownership and operation of water and power sources can be rated not only as a valued public service enterprise, but also as an excellent business investment.

San Francisco Water and Power today fulfills the prophecy of J. Waldo Smith, the Chief Engineer of the Board of Water Supply of New York City, who commended the City's engineers in 1933, forecasting: "When the project is completed, it will stand as one of San Francisco's greatest assets, and as a lasting monument to the energy of the City and its citizens and to their faith in the future."

General Managers — Chief Engineers

San Francisco City Water Company

1858-1860	Alexei Waldemar von Schmidt

Spring Valley Water Works

1860-1864	Alexei Waldemar von Schmidt
1864-1866	Calvin Brown
1866-1908	Hermann Schussler
1911-1914	Fred C. Herrmann
1914-1930	George A. Elliott

San Francisco Water Department

1930-1948	Nelson A. Eckart
1949-1957	George W. Pracy
1957-1963	James H. Turner
1963-1965	Oral L. Moore (acting management responsibility)
1963-1965	H. Christopher Medbery (acting engineering responsibility)
1965-1976	Arthur H. Fry, Jr.
1976-1978	Kenneth R. Boyd
1978-1984	Eugene J. Kelleher
1984-1985	Arthur Jensen (acting)
1985-	Dean W. Coffey

Water Department — Senior Staff

Arthur Jensen	Deputy General Manager
Raymond Quan	Senior Engineer, Resources and Planning
Robert Vasconcellos	Manager, Commercial Division
James Cooney	Manager, City Distribution Division
Shank Gupta	Acting Manager, Water Quality and Peninsula Division
Edward L. Fonseca	Manager, Suburban Operations Division
Tandy Carter	Assistant Manager, Alameda Division

HETCH HETCHY WATER AND POWER SYSTEM

General Managers — Chief Engineers

1912-1932	Michael M. O'Shaughnessy
1932-1942	Lloyd T. McAfee
1942-1945	James H. Turner
1945-1952	Axel O. Olson
1952-1961	Harry E. Lloyd
1961-1979	Oral L. Moore
1979-1985	Dean W. Coffey, (management responsibility)
1985-	Theodore L. Chung (acting)

Hetch Hetchy Senior Staff

Theodore L. Chung	Deputy General Manager
Alton L. Walter	Actg. Superintendent, Project Operations
John V. Hope	Superintendent, Power and Plant
Joe F. De Graca	Manager, Light, Heat and Power

PUBLIC UTILITIES COMMISSION

Utilities General Managers

1932-1945	Edward G. Cahill
1945-1956	James H. Turner
1956-1958	T.N. Bland
1959-1964	Robert C. Kirkwood
1964-1970	James K. Carr
1970-1976	John D. Crowley
1977-1979	John B. Wentz
1979-1983	Richard Sklar
1983-	Rudolf Nothenberg

San Francisco Water and Power
By Warren D. Hanson

Of the many qualified authorities, former Public Utilities Commission employees James H. Leonard and Ted Wurm must be singled out for special recognition for their editorships of previous editions of Water and Power in 1979 and 1967. Mr. Wurm's 1973 "Hetch Hetchy and its Dam Railroad" is also a valuable reference source.

Additional sources include:

San Francisco Water, published quarterly 1922-1930 by Spring Valley Water Company, Edward F. O'Day, editor.
Water and Power, published for the Public Utilities Commission by the Bureau of Engineering, 1947 and 1935.
Annual Reports of the Bureau of Engineering, Board of Public Works, 1908-1932
San Mateo County Historical Association, College of San Mateo.
Society of California Pioneers.
Congressional Record — 1893/1894; 1899/1900; 1912/13
"Hetchy Hetchy" by R.W. Taylor
History of California, Hubert Howe Bancroft
Annual Reports of the San Francisco Water Department
Annual Reports of the Public Utilities Commission
Municipal Reports, 1850-75

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1924 May	Pulgas Tunnel completed
1924 Aug 28	Upper Crystal Springs Dam Tunnel restored to use
1924 Oct 7	$10 million bond issue for Foothill and Coast Range Tunnels approved 20 to 1
1925 Apr 10	Early Intake Diversion Dam completed
1925 May 2	Moccasin Power Tunnel completed
1925 Jun 1	Moccasin Penstock completed
1925 Jun 2	Mountain Tunnel complete — first water passes to Priest Reservoir
1925	Calaveras completed to height of 215 feet
1925 Aug 14	Moccasin Powerhouse complete — begins commercial operations
1925 Sep 12	Bay Crossing Pipeline #1 placed in partial service
1925 Nov 27	Hetch Hetchy moves from Groveland to Hetch Hetchy Junction
1926 Feb 4	Foothill Tunnel starts from Pedro west face
1926 May 21	Bay Crossing Pipeline #1 enters full service
1927 Apr	Construction of Coast Range Tunnel starts
1927 May	Construction of Mocho Shaft on Coast Range Tunnel starts
1928	San Andrés Dam raised to 105 feet
1928 May 1	$24 million bond issue for Coast Range Tunnel and San Joaquin pipelines approved 7 to 1
1928 May 1	$41 million bond issue to buy Spring Valley Water Company approved 4 to 1
1928 Jul 19	Construction of Moccasin Dam starts
1928 Dec 6	Foothill Tunnel holed through
1929 Sep	Foothill Tunnel completed
1929 Nov	Moccasin Dam and reservoir completed
1930 Mar 3	San Francisco purchases Spring Valley for $39.96 million — Water Department created under Board of Public Works — Nelson A. Eckart named General Manager and Chief Engineer
1931	Second outlet gate tower built at Crystal Springs Reservoir
1931	U.S. Geographic Board re-declares name of San Andrés to be San Andreas
1932 Jan 8	New City Charter places Hetch Hetchy and Water Department under Public Utilities Commission — Edward Cahill appointed Utilities General Manager, Lloyd McAfee named General Manager and Chief Engineer of Hetch Hetchy
1932 May 3	$6.5 million bond issue to complete Hetch Hetchy Aqueduct approved 14 to 1
1932 Jul 9	San Joaquin Pipeline #1 completed
1933 Nov 7	Two bond issues — $3.5 million to enlarge O'Shaughnessy Dam, and $12.095 million to construct second Bay Crossing Pipeline, Crystal Springs Pipeline, distribution system reservoirs and improve the distribution system — approved 2.5 to 1
1934 Jan 5	Coast Range Tunnel holed through from Mocho to Mitchell shaft
1934 Feb 24	Alameda Creek Siphon completed
1934 Aug 24	Construction of Bay Crossing Pipeline #2 started
1934 Oct 12	Michael M. O'Shaughnessy dies at age 70
1934 Oct 19	First Hetch Hetchy water passes through Coast Range Tunnel to Alameda Creek
1934 Oct 24	First Hetch Hetchy water flows into Pulgas Water Temple 10:12 a.m.
1934 Oct 28	Hetch Hetchy water delivery to San Francisco celebrated at Crystal Springs Lake
1935 Nov 18	Construction starts on Moccasin diversion works
1935 Dec 10	PG&E disconnected from Early Intake Powerhouse — output pooled with Moccasin
1936 Jun 22	Bay Crossing Pipeline #2 completed
1936 Aug 31	Moccasin diversion works completed

SKETCHES
of the
SPRING VALLEY WATER WORKS

Respectfully dedicated
to
H. Wattson Esq. Sec.ty

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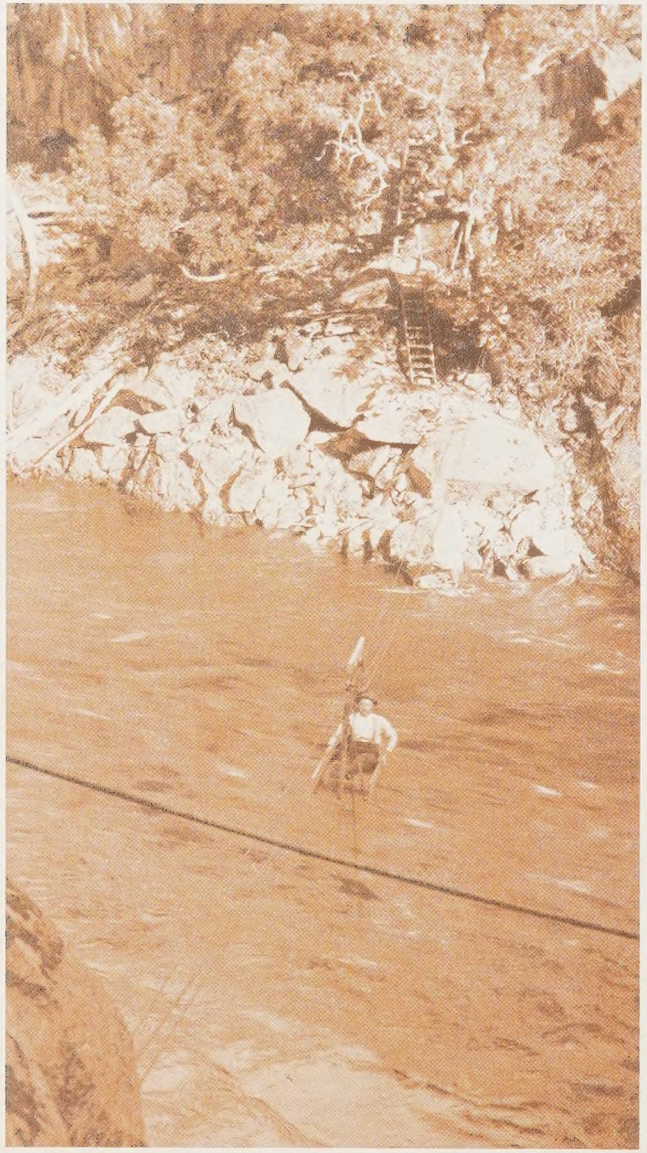
1936 Aug 31 Moccasin diversion works completed

1936 Dec 16 Interior Secretary Ickes approves plan 7 to dispose of Hetch Hetchy electrical power
1938 Jul 1 O'Shaughnessy Dam raised 85.5 feet — capacity 360,000 acre feet
1942 James H. Turner named General Manager and Chief Engineer of Hetch Hetchy
1943 Jul Turlock and Modesto Irrigation Districts participate with San Francisco and Corps of Engineers in Tuolumne River flood control
1945 James A. Turner appointed Utilities General Manager
1945 Axel O. Olson named General Manager and Chief Engineer of Hetch Hetchy
1945 Jun 22 Exploratory work at Cherry River damsite starts
1945 Jul 2 Interior Secretary approves new power disposition contracts as being in compliance with the Raker Act.
1946 May 11 Hetch Hetchy starts power delivery to Modesto's Station J
1947 Nov 4 $25 million bond issue to construct San Joaquin Pipeline #2 and Bay Division Pipeline #3 approved
1949 George W. Pracy named Water Department General Manager and Chief Engineer
1949 Hetch Hetchy Railroad tracks removed
1949 Nov $4 million bond issue to construct Cherry Valley Dam — Federal aid to be $9 million
1950 Jun 9 PUC holds ceremony and opens 33.3 miles of San Joaquin Pipeline #2 west of Oakdale
1950 Dec Rock River Lime Treatment Plant completed
1951 Jun Construction of 22,000 volt power line from Early Intake to Cherry Valley damsite starts
1952 Harry E. Lloyd named General Manager and Chief Engineer of Hetch Hetchy
1952 Oct 17 San Joaquin Pipeline #2 enters service for entire 47.5 mile length
1953 Mar 25 San Joaquin Pipelines #1 and #2 operated jointly for the first time
1953 Aug Construction of Cherry Valley Dam starts
1954 May 18 Cherry Creek water diverted at damsite
1955 Oct 27 Cherry Valley Dam dedicated
1955 Nov 8 $54 million bond issue to construct Canyon and Cherry River power projects
1956 T.N. Bland appointed Utilities General Manager
1956 Bay Crossing Pipeline #3 completed
1956 Mar 15 First joint operation of Hetch Hetchy and Lake Lloyd reservoirs for flood control
1957 James H. Turner named Water Department General Manager and Chief Engineer
1957 Aug 30 Construction of Cherry Power and Eleanor-Cherry tunnels started
1958 Sep 16 Construction of Cherry Powerhouse started
1959 Robert Kirkwood appointed Utilities General Manager
1959 Jan 26 Cherry Power Tunnel, 29,278 feet long, is holed through
1959 Apr 6 New transmission line — Early Intake to Moccasin — completed
1959 May 18 Eleanor-Cherry Tunnel, 5,854 feet long, is holed through
1960 Mar 6 First water diversion to Lake Lloyd through Eleanor-Cherry Tunnel
1960 Apr 16 New transmission line — Moccasin to Modesto's Station J — completed
1960 Jun 17 Cherry Power and Eleanor-Cherry tunnels completed
1960 Aug 1 Cherry Powerhouse begins commercial operation
1960 Aug 25 Early Intake Powerhouse ceases operation after 46 years
1961 Oral L. Moore named General Manager and Chief Engineer of Hetch Hetchy
1961 Feb 24 Water delivery to Lawrence Livermore National Laboratory from Mocho Shaft starts
1961 Nov 7 $115 million water system bond issue approved 19 to 1

1963 Oral L. Moore named Water Department acting General Manager — H. Christopher Medbery named Water Department acting Chief Engineer
1964 Jun 24 Canyon Power Tunnel, 54,888 feet long, is holed through
1965 James K. Carr appointed Utilities General Manager
1965 Arthur H. Fry, Jr. named Water Department General Manager and Chief Engineer
1965 Feb 26 Canyon Power Tunnel completed
1965 Jun 30 A new record for Hetch Hetchy water delivered to Water Department — 220 million gallons per day
1965 Nov 3 First water to Groveland Community Services District from Second Garrotte Shaft
1967 Mar 1 Robert C. Kirkwood Powerhouse starts commercial operation
1967 Sep 1 Construction on New Don Pedro Dam starts
1968 Mar 29 San Joaquin Pipeline #3 enters service — 300 million gallons per day can be delivered to west end of Coast Range Tunnel — maximum delivery limited to 280 million gallons per day, the capacity of the Bay Division pipelines
1965 Turner Dam completed to 195 feet forming San Antonio Reservoir
1966 Sep 14 Sunol Filtration Plant activated
1969 Jan 27 New Moccasin Powerhouse begins operation
1969 Feb 7 Old Moccasin Powerhouse taken out of service after 44 years
1970 John D. Crowley appointed Utilities General Manager
1970 May 28 New Don Pedro Dam topped out
1971 May 22 New Don Pedro Dam dedicated
1972 Pilarcitos Dam upstream face repaired
1972 Jun 14 Bay Crossing Pipeline #4 completed
1972 Aug 8 San Andreas Filtration Plant activated
1975 Water Department strengthens Calaveras Dam to meet current earthquake standards
1975 Jul 1 Main PG&E contract covering power wheeling, supplementary energy and standby service renegotiated and extended
1976 Kenneth R. Boyd named Water Department General Manager and Chief Engineer
1976 Sunol Filtration Plant expanded to 160 M.G.D.
1976 Crystal Springs Dam designated Historic Civil Engineering Landmark
1977 John B. Wentz appointed Utilities General Manager
1977 Nov Seismic study of Lower Crystal Springs Dam completed
1978 Eugene J. Kellerher named Water Department General Manager and Chief Engineer
1979 Richard Sklar appointed Utilities General Manager
1979 Dean W. Coffey named General Manager of Hetch Hetchy
1980 Jan Phase I seismic study of San Andreas Dam completed
1980 Sep Suburban Division moves into new headquarters building in Millbrae
1981 Feb Water quality laboratory moves to suburban headquarters in Millbrae
1982 Feb San Andreas Pipeline #3 placed into service
1983 Rudolf Nothenberg appointed Utilities General Manager
1983 Feb Phase II seismic study of San Andreas Dam completed
1983 Jun Seismic study of Pilarcitos Dam completed
1983 Fall Environmental assessment prepared for proposed 1.5 megawatt plant ($5 million budget) at O'Shaughnessy Dam
1984 Spring Engineering design starts for third generator at Kirkwood Powerhouse
1984 Spring Construction starts on powerline from new Moccasin Low-Head Hydro Project
1984 Sep Arthur Jensen named Water Department acting Manager
1984 Nov Voters approve $104 million water system revenue bonds 179,087 to 55,651, to build Crystal Springs Filtration Plant and balancing reservoir, and increase capacity of San Andreas Filtration Plant



Pilarcitos Dam, Winter 1866-7
Showing reservoir, former waste weir in operation, and camp.
No. 2.